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No. 3757 VOL. LXXIII.

FRIDAY, NOVEMBER 21, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

ONE-HUNDRED-AND-SEVENTY-FIRST SESSION, 1924-1925.

PATRON—HIS MAJESTY THE KING.

VICE-PATRON—H.R.H. THE PRINCE OF WALES, K.G.

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Auditors—Messrs. Knox, Cropper & Co.

NOTICES.

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NEXT WEEK.

Monday, November 24th, at 8 p.m. (Cantor Lecture.) Louis C. Martin, D.I.C., A.R.C.S., D.Sc., Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and Technology, South Kensington. (Lecture I.)

Wednesday, November 26th, at 8 p.m. (Ordinary Meeting.) C. F. Elwell, B.A., "Talking Motion Pictures" (with Practical Demonstrations). Alan A. Campbell Swinton, F.R.S., late Chairman of the Council, will preside. [Films will be exhibited showing dancers dancing to music, people speaking words, playing the violin, etc., with perfect synchronisation between the actions and the sounds.]

CHAIRMAN'S INAUGURAL ADDRESS.

The Chairman's Inaugural Address, which had to be postponed owing to the unavoidable absence abroad of Senatore Guglielmo Marconi, G.C.V.O., LL.D., D.Sc., will be delivered on Thursday, December 11th, at 8 p.m. The subject of the Address will be announced later.

The Swiney Prize and the medals awarded for papers read during the past session will be presented.

Tea and coffee will be served in the Library after the meeting.

COUNCIL.

A meeting of the Council was held on Monday, November 10th. Present:—Senatore Guglielmo Marconi, G.C.V.O., LL.D., D.Sc., in the Chair; Lord Askwith, K.C.B., K.C., D.C.L.; Sir Frank Baines, C.V.O., C.B.E.; Captain Sir Acton Blake, K.C.M.G., K.C.V.O.; Sir William Henry Davison, K.B.E., D.L., M.P.; Sir Archibald Denny, Bt., LL.D.; Sir Edward A. Gait, K.C.S.I., C.I.E.; Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.; Major Sir Humphrey Leggett, D.S.O., R.E.; Sir Philip Magnus, Bt.; Sir Charles C. McLeod; Mr. James Swinburne, F.R.S.; Mr. Alan A. Campbell Swinton, F.R.S.; Mr. Carmichael Thomas; Dr. J. Augustus Voelcker, M.A.,; and Sir Philip Watts, K.C.B., LL.D., F.R.S., with Mr. G. K. Menzies, M.A., (Secretary of the Society) and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

A Committee was appointed to prepare a scheme under the Thomas L. Gray Bequest. (Further particulars of this Trust will be printed in a subsequent number of the *Journal.*)

The Secretary was nominated to represent the Society at a Conference on Architectural Studentships, etc., called by the Board of Architectural Education.

Papers to be read at the meetings after Christmas were considered.

Other formal business was transacted.

PROCEEDINGS OF THE SOCIETY.

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FIRST ORDINARY MEETING.

WEDNESDAY, NOVEMBER 12TH, 1924.

MR. ALAN A. CAMPBELL SWINTON, F.R.S. (late Chairman of the Council), in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Armitage, Evrard Leathley, Farnham, Surrey.
Ayres, Norman Frederick, B.Sc., Abadan, Persia.
Barnes, George Charles, Harpenden, Herts.
Bolton, Scriven, F.R.A.S., Bramley, Leeds.
Bong Liong See, John, Oxford.
Calder, John J., London.
Cartwright, James Stewart, Cape Town, S. Africa.
Casacof, Christo, M.Am.Soc.M.E., New York City, U.S.A.
Childs, C. B. M., London.
Chotai, Bhimji Keshavji, Una, Kathiawar, India.
Cox, President Harvey W., A.M., Ph.D., Emory University, Georgia, U.S.A.
Crane, Professor James Wellington, M.B., London, Ontario, Canada.
Craven, Thomas Ernest, Keighley, Yorks.
Cropper, Miss, L.L.A., Uxbridge.
da Fonseca, Dr. Eurico Teixeira, Rio de Janeiro, Brazil.
Duckworth, Harold, Ashton-under-Lyne.
Esserman, Nouman Abraham, Victoria, Australia.
Evans, John, Trinidad, British West Indies.
Field, Leslie William Howard, London.
Gan Khek Keng, Singapore, Straits Settlements.
Gill, Colonel William Smith, C.B., R.E., Bieldside, Aberdeenshire.
Glass, George William, Delhi, India.
Goodfellow, Magnus, London.
Hall, Ralph, Calcutta, India.
Hallett, Leonard Richard, L.D.S., Uckfield.
Hanaghan, Jonathan, Birkenhead.
Homberger, Professor Alfred W., A.B., M.S., Ph.D., Louisville, Kentucky, U.S.A.
Hopkins, George Alexander John, London.
Isaacs, Godfrey C., London.
King, George Frederick, London.
Klein, René H., M.Inst.R.E., London.
Knight, Henry James, Worcester.
MacEchern, Fergus Norman, London.
Manning, Perciva L. H., Nandod, (Gujrat), India.

Marten, John T., M.A., I.C.S., Fleet, Hants.
Metcalfe, Mrs. Blanche, London.
Murray, His Excellency John H. Plunkett, C.M.G., Port Moresby, Papua.
Nasikvala, Fram D., Bombay, India.
Nyun, Maung, Katha, Burma.
Ogden, Agnew J. T., Tiverton, Devon.
Oliver, John G., L.S.A., Greenock.
Orchiston, J., M.I.E.E., Wellington, New Zealand.
Pearson, Archibald Ramsden, London.
Pope, Sir William J., K.B.E., D.Sc., LL.D., F.R.S., Cambridge.
Pugh, F., Winnipeg, Canada.
Reid, E. Everett, London.
Relly, Owen Hamilton, Eastbourne.
Rivers-Moore, Henry Rivers, Croydon, Surrey.
Roscoe, Rev. J. E., M.A., B.Litt., Bacup, Lancashire.
See Beng Kam, Malacca, Straits Settlements.
See Wee Yan, Malacca, Straits Settlements.
Shome, M. L., Dacca, India.
Sng Tiong Geok, Singapore, Straits Settlements.
Stephenson, William Samuel, London.
Stoneman, Walter, London.
Tan Chong Lek, Malacca, Straits Settlements.
Thacker, Maneklal S., London.
Town, Harold C., Keighley, Yorks.
Townley, Mrs. Charlotte D., Croydon, Surrey.
Vasavada, R. M., Ludhiana, Punjab, India.
Weeden, Sydney Alexander, London.
White, George Starr, Los Angeles, California, U.S.A.
Whitfield, Horace Henry, Birmingham.
Worthington, Walter Scott, Enfield, Middlesex.
Wright, Cedric Alfred, Ashford, Kent.

THE CHAIRMAN said that Colonel Crompton required no introduction from him. As everybody knew, he was one of the veteran engineers in England, chiefly known for his later work in electrical design and manufacture, and also as a pioneer in electricity supply. That night, however, he was going to talk about pioneer work of another kind on which he embarked when many of those present were in their cradles.

The paper read was:—

THE MOTOR CAR: ITS BIRTH, ITS PRESENT, AND ITS FUTURE.

By COLONEL R. E. CROMPTON, C.B., R.E., M.Inst.C.E., M.I.E.E.

Although I am only one of many who are able to discourse on the present and future of the Motor Car, I am one of the few left who can speak with authority on its birth and gradual development up to the present time. For I propose to show to you that in this country the road locomotive was developed before the railway locomotive, and that if it had not been for the other road interests and for the coming of the railway we should and, I think, still ought to be able to claim for England the title of being the real parent of Automobilism and transport by road. I will not take up your time by discussing the work of Hancock, Gurney, Ogle and others during the years 1825-35, for much has been written about the good work done by these men. It was my privilege to be a colleague of the late Sir Frederick Bramwell, who actually himself when a pupil worked on the Hancock road engines about the year 1827, and he told me how advanced Hancock was in all his ideas of producing satisfactory boilers of light weight for road locomotive purposes.

When visiting the Royal Agricultural Show at Leeds in 1861, I as a boy there seeing the first Agricultural Traction Engine, was fired with the ambition to produce a steam driven motor car for passengers which would travel at a reasonable speed. I began then to build such a car, and actually had it running on the road in England in 1863. I took it out to India with me and finished it as a complete car to run on the good roads of India at 20 miles an hour. It was this that made me personally correspond with R. W. Thomson, of Edinburgh, to whom I wish to assign the greatest share of the credit of introducing the modern road motor car, and the modern motor waggon on to our roads.

It may be said with truth that the coming of the automobile vehicle, whether motor car or motor waggon, which has revolutionised modern road transport really commenced with the invention of elastic tyres either made of solid rubber or in the form of pneumatic tyres in which air is used as the elastic medium, and it is the object of this paper to show that the real man to whom most of the credit for modern Automobilism is due was R. W. Thomson, of Edinburgh, and it is fitting that the author, who was associated with Thomson in the greatest of experimental developments should now put on record the great work carried out by him in the early '70's of last century.

Mr. R. W. Thomson was born at Stonehaven in 1822. He went out to America as a boy, but returned to England, and when only 16 years old showed great talent for invention in Engineering matters. He was therefore apprenticed as an Engineer in Aberdeen and Dundee, but in 1844, when only 22 years of age, he set up in business on his own account and a year later he conceived the idea of applying rubber tyres to ordinary vehicles. We read in Volume XLV of the *Mechanic's Magazine* that he applied noiseless tyres to a brougham which was then running in the London parks. He took out a patent for these pneumatic tyres in the year 1845, but at that time India-rubber was scarce and it was difficult to make what we now term the inner tubes of these pneumatics sufficiently air tight. He had great trouble with the manufacturers, Messrs. Macintosh and others, and on account of these difficulties of manufacture his invention made poor progress. The railway companies of that time adopted the tyres for the platform handcarts but paid Thomson no royalty.

In 1851, the first fountain pen, which was Thomson's invention, was shown and sold in the Great Exhibition. By 1862 he had got together a business as a consulting engineer and settled in Edinburgh. One of his first inventions was a portable lifting crane. He also designed what is believed to have been the first floating dock; this was sent out to the Dutch East Indies. In the course of his engineering work when developing certain collieries established at Labuan, he found it necessary to haul the coal from the collieries to the landing stage by some form of traction engine, and as the traction engines of that time were not suitable for traversing rough and uneven ground, and were very deficient in hauling power in proportion to the weight on the driving wheels, he returned to his older love, but as he could not even then have his pneumatic tyres manufactured with any reasonable certainty of success he turned his attention to a new kind of wheel This wheel consisted of a light wrought iron drum about 4 ft. diameter by 13 inches wide, having flanges 1 inch thick on either side, over which was slipped or stretched a flat India-rubber band 12 inches wide by 4½ inches thick. He then designed what he called a road steamer mounted on three wheels for the Labuan colliery work. He had this road steamer fitted with heavy ring rubber tyres at work in test in December, 1867, and the newspapers of the time pronounced it to be in advance of anything which had ever been put on the road. Numerous trials were made with this engine drawing a large 'bus behind it at the rate of 12 miles per hour. At that time, the author, who was in the army in India serving as a Lieutenant in the Rifle Brigade, had already constructed a motor car, which was really a steam carriage with wooden wheels with ordinary iron tyres. He completed this car; it was set to work to run on the good well-metalled roads of the Punjab, but seeing the accounts of the trials of the Thomson road steamers in the engineering papers of the day he got into correspondence with Thomson. The following year, having been appointed to the Commander-in-Chief's staff as his aide-de-camp, and being full of his road engine project, he talked it over with the Commander-in-Chief, and afterwards with Lord Mayo, who was then the Governor-General. Lord Mayo was an exceptionally liberal minded and far-seeing man of affairs, and interested himself so much that he suggested to the author that he should make a report to the Director General of Post Offices in India embodying a proposal for working by the Thomson engine the bullock trains which at that time were the only form of haulage, the railways of India having been only partially completed.

The author was fortunate in being able to persuade the Government of India to support his ideas, and authority was given to him to invite a tender from Thomson to send out a trial engine. Thomson agreed to do this provided the experiment was put into the author's hands. A department was accordingly formed called the Government Steam Train, and the author was appointed the first Superintendent.

The first Thomson road steamer arrived at Calcutta and was put together at the Alighar workshops during the year 1869, and as far as hauling power, good adhesion, and freedom from vibration when running at a considerable speed are concerned, the engine was successful. It failed, however, in that its small fire-box did not admit of the use of wood fuel, and as coal fuel was not available on the line chosen for the test, which lay between Amballa and Kalka, this, the first Government steam train engine, had to stop so frequently to raise steam that its speed was not much greater than that of the bullock train that it was intended to supersede. The author, feeling that this boiler failure was quite apart from Thomson's rubber tyre invention, spent many anxious weeks up at Simla endeavouring to persuade the authorities to give this road transport experiment another chance.

This chance was given, Lord Mayo himself signing the authority for the expenditure of a sufficient amount to purchase and equip with waggons and passenger vehicles several improved steam trains, four of which were to be ordered, the engines to be made in England to Thomson's design and specification, the waggons and remainder at the Government workshops at Alighar, in the North-West Provinces. Under the strain of the boiler disappointment, the author's health broke down, but the Government of India sent him to England at Government expense, to discuss with Thomson all the points in which road transport in India differed from that in England or any other country, of which but little experience was available.

The memorandum attached to the order for the large-scale experiment is interesting, and is quoted here verbatim, as it shows that the knowledge of road transport that had already been acquired was very considerable. The memorandum states that for Indian requirements we must have :—

1. Great lightness consistent with safety and economy of fuel and water. Simplicity of parts requiring renewal, capacity for ready repair on the road.

2. A further adaptation and improvement of the rubber tyres now used by Thomson, so as to increase their very perfect springing action.

3. The reduction of the wear and tear of highway which must follow from the use of elastic tyres.

4. The reduction of wear and tear of highway which would follow from improving existing friction brakes.

5. Further improvement of the Thomson chain shoes.

6. The best proportion of tyre diameter, width and thickness which, combined with the shoes, is necessary in order to get the best grip on the road for haulage purposes.

7. In view of the cost of rubber, can any arrangement of elastic wheels be devised to take the place wholly or partly of the rubber tyres ?

After interesting adventures, on his return voyage in 1870, when travelling across Europe in the rear of the German army, the author arrived in England and reported himself to the India Office, and a few days later saw R. W. Thomson for the first time. He now believes that on the day of his first interview with Thomson, modern road transport took a great step forward, a step which undoubtedly led to the huge development that has since taken place. At the time when he came home from India, although it is true that the agricultural engineers were building traction engines having broad steel tyres, these engines lumbered along with a man walking in the front of them carrying a red flag to warn other traffic, so that it was impossible for the driver to exceed the flagman's walking pace, namely 4 miles per hour. Owing to Thomson's work on the Indian steam train during the 18 months that the author was in England, such progress was made that the engines of the Indian Government steam train equipped with rubber tyres actually travelled at speeds up to 25 miles per hour, when carrying 100 passengers. During the same period the tractive effort, which on the rigid-tyred traction engines rarely reached as high as 30 per cent. of the weight on the engine driving wheels, was increased by the rubber tyre up to double this figure.

The author found that Thomson was an invalid, suffering from locomotor ataxy, so that he was unable to leave his sofa, though his brain was extraordinarily active. His wife was then helping him in his work, but when she found that the author was already her husband's faithful disciple, she asked him to help her in the propaganda work that Thomson had already started for developing road transport. The author stayed at Thomson's house for some months, in fact, until new designs had been prepared by Thomson to meet the Indian requirements. The leading draughtsman who was engaged to make the working drawings was Gustave Bremme. At that time, Kennedy, now Sir Alexander Kennedy, was in the drawing office at Tennants, at Leith, where one or two of the earlier Thomson road steamers had been constructed. The author found that the small type of Thomson road steamer, similar to the one that he had been testing in India, had already been improved, and Messrs. Robeys, of Lincoln, were then constructing one named "The Advance." After this engine was tried, the new type which Bremme drew out for the Indian requirements was again modified. The defects already noted in India and the memorandum which had been laid before the Indian Government served as a basis of discussion. A point on which the author differed from Thomson was the boiler to be used in India. Thomson did not at first appreciate the large grate-area required for burning wood fuel. He was then using a boiler of his own design called the "pot" boiler, which gave great trouble, whereas the author preferred to use the Field type of boiler that Messrs. Merryweather were then using on steam fire engines, and which he had himself used for his own engine built in India. The matter was compromised by Thomson starting on his own type for the first two engines, and the first trials were therefore made with the Thomson "pot" boiler. These were soon replaced by the Field type of boiler, which was adopted throughout and on the whole gave satisfactory results. A good many of the preliminary trials were made with Thomson's "pot" boiler, and this undoubtedly prejudiced the new form of road vehicle, because the delays and breakdowns, entirely due to Thomson's boiler, were put down by our rivals, the traction-engine people, to tyre troubles, which did not really exist. At the same time it is true that the new engines, being able to run at higher speeds than had been hitherto possible, made it possible for us to observe and study many of the phenomena connected with the use of rubber tyres, such as side-slip on a greasy road, heating due to rapidly repeated deformation, which only occurs at high speeds, and which in our case sometimes reached such a point that the rubber itself became decomposed (gases were given off and huge bladder-like wens were formed on the tyre surface).

The dimensions of the tyres of the new engines were as follows:—driving wheels over-all diameter, about 6 ft. 6 in.; width of rubber, 15 in.; thickness, 4½ to 5 in.

These engines were fully described and illustrated in a paper read by the present author before the Institution of Mechanical Engineers shortly after his return from India.* The building of the first engines was entrusted to Messrs. Ransomes, Sims and Head, of Ipswich, and by the middle of May, 1871, the first engine, the "Chenab," named after one of the Punjab rivers, was sufficiently advanced to be tried in a preliminary test on the roads near Ipswich. These trials were reasonably successful, but although coal was used as fuel it was evident that the boiler would not be able to make sufficient steam with wood fuel. In fact it was necessary to sharpen the blast so much that the "Chenab" became a fire thrower and set fire to the grand stand on the Ipswich race course, and the Government of India had to pay for a new one. Although it was then seen that the boiler in the "Chenab" was a failure, Messrs. Ransomes were so anxious to show one of these new engines at the Royal Agricultural Society's Show at Wolverhampton, that the "Chenab" was finished off for show purposes with the original "pot" boiler as designed by Thomson. By that time the author was so disgusted with this boiler that he arranged with Lewis Olrick to design and tender for the construction of Field boilers of the same external dimensions to be interchangeable with, and to fit into the same engine frames, having a sufficient number of Field tubes to give larger heating surface, and to hurry these boilers forward, so that one of them could be fitted into the second engine, called the "Ravee," by the end of May.

Early in the summer we started from Ipswich on the run to Wolverhampton having coupled to the engine a rubber-tyred omnibus, which had been built in Edinburgh to carry 130 people, 60 below and 70 above. This omnibus had only two rubber-tyred wheels, and the total combination of the three-wheeled tractor with the omnibus constituted a five-wheeled vehicle, which was therefore the first forerunner of the six-wheeled arrangements, that are now so much under discussion. This omnibus carried a considerable party, as there was ample room to use the lower part as a sleeping-room. In addition to the author and his wife were Bremme, the chief designer, and his wife, a pupil named

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* See Proc. I. Mech. E., 1879, pp. 494—533.

Attwood, a leading fitter, Tom Wooley, and a fireman named Pipe, and with the addition of one or two boiler-makers, the crew numbered 14 to 16 persons, for which the large bus became the dwelling-house.

On this first trip there were plenty of boiler troubles and a good deal of amusement. Eight days were occupied on this first run, which irreverent people called "Lieutenant Crompton's honeymoon trip." Throughout the journey the Thomson boiler gave infinite trouble, and the boiler-makers who accompanied us had to expand the vertical fire-tubes every night. This experience confirmed the author in his views that this type of boiler must be scrapped and the four engines fitted with the Field boiler that Olrick had already designed for them.

At the Wolverhampton R.A.S. Show the train attracted great interest. The engine and omnibus were taken to the various trials of the traction engines, and as Ransomes had prepared a Thomson rubber-tyred engine to plough by direct traction, the comparison between the rubber-tyred engine and the traction engines used by Aveling and others, who fitted their driving wheel with paddles, was interesting and instructive. The rubber-tyred engines scored in dry weather, but in wet weather the older type with paddles were victors. In the tests which took place on the hard road, however, there was no comparison between the hauling power of the two types of engines, so that an engine designed by Ransomes for agricultural purposes, fitted with Thomson tyres, was awarded a special medal for its excellent performance. We used the "Chenab" to carry the judges about, the omnibus serving as the judges' office, and if it had not been for the trouble with the boiler the vehicle would have received a great deal of credit. The perpetual boiler breakdowns caused the author to send the "Chenab" home by rail to Ipswich, to have a Field boiler fitted.

About this time the author met a Mr. Muirhead, who was the engineering instructor at Farnah Hall, Derby, and thought that he would be a likely man to act as assistant engineer of the Government steam train; he would follow the author out to India with the remaining three engines, as the author was urgently wanted in India to build the waggons and design the workshops required for the extended experiment.

By August, 1871, the "Ravee," the second engine, was ready for trial with a Field boiler. It was fitted with a sufficiently good spark-arrester, and made ample speed when wood fuel was used, but when burning coal we were obliged to block off the centre of the fire grate.

On August 19th, we started on what might be called the first really satisfactory long run on a highway. This was from Ipswich to Edinburgh, in order that Thomson might himself be able to see one of his engines on the road. Our actual start was made on September 13th, with the same large omnibus, making the five-wheeled arrangement. With the "Ravee" we were able to slash along at a great pace, practically only limited by the requirements of the traffic. Through the influence of the Government of India we were armed with a permit to carry on road tests with these engines at speeds above those allowed by the Red Flag Act, and we soon found that on open stretches of level road we could get up to speeds exceeding 20 miles per hour. On this trip we found that when we ran with bare rubber tyres, which we were able to do in dry weather, the rubber rolled out in front of the driving wheels and actually left the polished steel treads, so that the engine practically ran on the upper surface of a continuous track resembling the modern caterpillar track. We were then really forestalling arrangements that have been quite recently introduced by the Citroen Company for their most recent track-laying cars, designed with belt-tracks for crossing deserts. At first we attempted to travel through the night, but had some dangerous adventures on narrow embankments in the Fen district. Near Stamford, Muirhead joined us, with Mr. Montford and some of his pupils. On the way to Doncaster the highest speed ever made on a highway, that is, over 25 miles per hour, was recorded. The route was on the Great North Road at points where it ran parallel to the Great Northern Railway, and the road train overtook and passed several goods trains travelling in the same direction; as the load and train together weighed about 40 tons, this constituted a record in road locomotion both for speed and power developed. The night was passed at Doncaster. Next day, on Bramham Moor, a curious phenomenon was noticed; the engine and omnibus being insulated from the earth by its rubber tyres, acquired a high static electrical charge, so that any one standing on the road, on touching the engine, took a strong spark and electrical shock, which was startling but not really dangerous. By allowing a wire to hang so as to touch the ground the static charge disappeared. The run to Edinburgh was made without further trouble, and sufficient time was spent in Edinburgh for Thomson himself to inspect the train and to carry out some careful tests of the hauling power of the "Ravee," the load being a train of waggons borrowed from contractors. The tests were on an incline near Edinburgh, called Soutra Hill. In these tests a coefficient of adhesion was obtained of 60 per cent. of the weight on the driving wheel.

At this trial the total weight of the engine and omnibus was about 19 tons.

	Ipswich to Edinburgh	Edinburgh to Ipswich
Total fuel consumed in lbs.	29,148	25,312
Total water evaporated in lbs.	137,850	144,300
Total distance in miles	422.5	424
Time actually travelling	77h. 26m.	61h. 13m.
Engine standing under steam	72h. 23m.	42h. 3m.
Average speed in miles per hour	5.45	6.9
Gross load in tons	19	20

Mile tons	8027.5	8480
Lbs. of coal per ton per mile	3.631	2.98
Lbs. of water per ton per mile	17.17	17.01
Lbs. of water evaporated per lb. of coal ...	4.729	5.7

By the return journey the men had ample experience in working the engine, and the 425 miles took nine days, giving 47 miles as the average distance per day, and a speed of about seven miles per hour for the time actually running; but on the last day the average speed was about ten miles an hour, whilst occasionally a speed of from 15 to 20 miles per hour was maintained for short distances.

Throughout this complete round journey from Ipswich to Edinburgh and back, of nearly 700 miles of road, the above data were taken as to fuel consumption, speeds and loads, which were considered satisfactory. After finishing up other work, the author went on in advance to India, instructing Muirhead to complete the other engines and to follow him when they were ready.

The spring of the year 1872 was occupied in preparing the necessary premises for running the Government steam train between Rawal Pindi, the principal military station in the Punjab, and Attock, where the trunk road crosses the Indus, a distance of about 70 miles.

The original programme was that as there was considerable traffic both in goods and passengers between Rawal Pindi and the frontier station at Peshawar, this section should be worked by the Government steam train, in place of the bullock train that had been used for goods haulage, and the Dâk Gharris on which passengers up to that time had had to travel.

In the early portion of this year two of the new engines arrived, but the road haulage system did not get to work until the autumn of 1872. Within two months of starting the first troubles began; the crankshafts of the "Ravee" and of the other engine broke, due to torsional stresses set up in the mild steel then used. At that time it was thought that as the driving wheels could slip to a certain extent inside their tyres, a differential gear was unnecessary, but this view proved to be mistaken, for although this slip undoubtedly did take place and was sufficient to allow of accurate steering round curves of great radius, on curves of small radius the drivers were instructed to throw out of gear the wheel on the inner side of the curve, but the drivers did not always obey orders, and undoubtedly this was the cause of the crankshaft failures. Curiously enough, the head of the Post Office, under which the Government steam train was working, Mr. A. M. Monteith, who had considerable mechanical ingenuity, brought to the author several designs for arranging a differential mechanism in the crankshaft itself, but for want of means for making the necessary forgings, and of the complicated machinery required, his designs were not then carried out; they were, however, identical in every way with a crankshaft so fitted shown on the Super-Sentinel steam waggon at the Commercial Vehicle Show in 1923.

The crankshaft trouble was dealt with by altering the ratio of the gearing of the countershaft and instructing the drivers always to run with the countershaft in gear, removing the pinions from the crankshaft, and in this way the crankshafts were saved, but the countershafts although they had a longer life, failed from the same cause after a given mileage.

During the following year, when war threatened with the Amir of Afghanistan, the military authorities decided to hold a camp of exercise at Hussun Abdul, halfway between Rawal Pindi and Attock. One reason for choosing this point was that they could thoroughly test the capacity of the Government steam train for moving troops, guns, and military stores. This Hussun camp of exercise gave work for the steam train during the winter of '73, and there is no doubt that the excellent work then done was the cause of Lord Roberts, who was at that camp, advocating the use of mechanical transport for our Army during the Cape War in 1900; in fact, Lord Roberts informed the author that this was the case.

After the camp of exercise during the years '74—'75, the steam train was employed for regular haulage and passenger service. The cost in those days was considered high, but would at the present time be considered quite satisfactory.

In the early part of the year '73, the Government of India appointed a committee of inquiry to sit at Rawal Pindi to examine the whole question of the progress made up to that date by the Government steam train, as it was then developed.

Among the references to the committee were its hauling capacity as compared with a light railway; the cost of working per ton as shown by the monthly accounts up to that date; the causes of such mechanical failures as had then occurred, and the extent to which these could be avoided in the future; the extent to which working costs were likely to be reduced on an increased scale of working and with greater experience, and the facilities afforded by mechanical transport for military purposes in case of war in India itself or in the case of a frontier campaign. The committee consisted of the then head of the Calcutta mint, Colonel Hyde, R.E., as chairman; Mr. Joseph Harrison, who was then the leading expert on Indian railway matters, and Major Limund, R.E., who was the Superintending Engineer of the 8th Circle Military Works, and one or two other officers. This committee went very fully into the history of the steam train, examined the accounts and witnessed a number of working tests which were suggested to illustrate the capacity of the train to carry goods at 6 m.p.h. speeds, and to carry troops and passengers at higher speeds.

The report of this committee was, on the whole, so favourable that everyone including the author, believed that the Government steam train experiment would be continued on a largely increased scale. In the year 1875, however, the period for which the author had been seconded from active service with his regiment expired, and he was ordered to rejoin his regiment.

After the author left for England, his assistant, Mr. Richard Muirhead, carried on the work of Superintendent of the train for several years, in fact, until the period at which the craze for light railways, substituting the metre gauge for the existing Indian broad gauge, caused the Government of India to decide that the road steam train would be no longer necessary. The engines and plant were then handed over to the Northern State Railway.

As far as the author is concerned, this great experiment in road transport terminated in 1875, and although, for the reasons above given, it did not at the time lead to any great development of mechanical road haulage either in England or in the Colonies, it is practically certain that the reports of Colonel Hyde's committee and the good services rendered by the trains in transporting troops and stores at the Hussun Abdul camp of exercises did greatly impress the military authorities of India, including General Roberts, who was then on the Quartermaster General's staff. The evidence of this came 25 years later, in 1899, on the outbreak of war in South Africa, when Lord Roberts, as he had then become, quickly realised that for the great distances to be traversed, the difficulty of feeding transport cattle, and the great weight of modern artillery and machine guns with their ammunition required special means of transport, and Lord Roberts's own recollection of what the author did with the Government steam train in India in the seventies, caused him to put the author in charge of the small instalment of mechanical transport which had been taken to South Africa by Colonel Templar as part of the equipment of the Balloon Corps. The work then done by the mechanical transport under the author's charge so impressed the War Office authorities in England that they asked Lord Roberts to send the author home to organise mechanical transport for the Army, and from that date mechanical transport for the army has steadily increased up to the position which it occupied in the last great war, in which it may be safely said it completely ousted animal haulage except for a few special purposes.

The author, in his opening remarks, stated that Thomson's work commenced in the sixties of last century was carried on by the Government steam train in India without interruption up to the year 1878, or thereabouts, and constituted a chapter in the history of road transport which can never be forgotten. For through that period not only were most of the problems inherent to the use of rubber for tyres encountered and to some extent successfully solved, but many other phenomena which have to be mastered before road trains consisting of more than one vehicle can be successfully worked on our existing roads were then investigated, and established the basis for regular service. For instance, the Rawal Pindi-Attock road trains tested in the presence of Colonel Hyde's committee consisted of nineteen vehicles, and of the total gross moving load on the road of over 70 tons, 40 tons was the net paying load. The difficulties of manœuvring such long trains were at first considerable. When running on the level or descending inclines at a high speed there was a tendency for any slight lateral movement of the coupling-pin in the rear of the engine to exaggerate itself backwards through the train, so that when these long trains were first used the side oscillations of the rear waggons would be so great as to throw them off the road. This difficulty was dealt with by careful proportioning of the distance from the centre of the rear wheels of each vehicle to the coupling point, and similarly from the centre of the front wheels of the vehicle following up to the same coupling point. In addition to this, coupling-brakes were fitted on the turn-tables of the front wheels of each vehicle, so that towards the close of this great experiment there was no difficulty experienced in running these long trains at high speeds, and the danger from the side oscillation at first observed was eliminated.

The improvement of the tyres themselves, in the shape of their cross section, and in the method of attachment to the wheels, and also of the protecting shoes or armour which were from time to time modified by the combined work of Richard Muirhead and the author, had the ultimate effect of reducing the total tyre cost per mile run to about half of the figure noted during the first year of running.

In those days it was found best to let the rubber expand forward under the rolling action of the wheel, and then to pass back over the top of the wheel, the friction on the inner surface being taken up by transverse metal rods covered with anti-friction bearing metal; in this manner the wear, which up to that time had taken place largely on the inner surface of the rubber tyres, was transferred to these transverse rods, which could be easily and cheaply renewed.

The external protecting armour of the tyres (then known as the "shoes") was gradually modified from the chain-like form originally adopted by Thomson, which gave endless trouble, due to link wear, and an entirely new form, called clip shoes, was adopted; these were not linked together, but were held in position by having their outer ends turned up and hooked outwards and held in circumferentially by steel hoops slipped over the hooked ends.

It will be seen that the great strides made by the use of Thomson's inventions in Road Transport were only possible at that time because the conditions of road transport which rule in our great Indian Empire are wholly different from the conditions that then prevailed in England. In India there was no legal limitation to speed; the Grand Trunk road is laid out with easy and regular gradients, its metalled surface is smooth well-formed and consolidated. Hence it was not unreasonable to expect that if high speed engines could be made successful anywhere they would be so under such favourable conditions.

From what I have said it is clear that these expectations were fully realised by us at the early period. During the years between 1871 and '75 high speed was obtained without excessive wear and tear, very regular running and timing were observed, great numbers of passengers were conveyed cheaply and safely, and goods were carried at a cheaper rate than by any land carriage other than rail.

In India it was found advisable to reduce the weight of the loaded engines from 14 tons, as they were first erected in Rawul Pindi, down to 9 tons, as it was considered that the former weight was too great for the timber bridges of the Trunk Road. Moreover the excessive weight on the driving wheels of the engines greatly reduced the life of the rubber tyres. So that at an early date separate 4-wheeled tenders carrying 500 gallons of water and a supply of wood fuel were made. This reduced the total weight of the engines by 5 tons.

There were few accidents; once a driving wheel came off, twice a train became uncoupled and once the English soldier driver got drunk, and drove his engine off the road, the engine being turned upside down and considerably damaged. It was a tedious job to repair the engine after this last accident, but after the repairs it was worked for 9 weeks running night and day, covering nearly 2000 miles without coming into the repair shed. Another point interesting to notice is how trustworthy the native drivers became; whereas with European drivers we had narrowly escaped having two terrible accidents, entirely due to the curse of drink; the Mohammedan drivers did not drink; drove steadily and could be thoroughly depended on.

Enough has been said to show that this great experiment was the real precursor of modern road transport and that if it had not been for the prohibitive legislation that held at the time of the author's return to England in 1875, he was then in a position to do all that has been done since in extending road transport as far as it has been done by the steam motor waggons of the Foden, Sentinel, Burrell and Aveling types with which we are now so familiar. It is true that the use of the internal combustion engine came later, but it is an entire mistake to suppose that the road motor was due to the genius of the French. Whereas if the French had not had the successful work of Thomson before them they would have had to wait for the later reintroduction of Pneumatics by Dunlop and Michelin, and still later for the reintroduction of the solid Ring tyres that we now see everywhere on commercial vehicles.

It will perhaps interest my audience, who for some years past have grown accustomed to seeing all our highways covered with automobile vehicles ranging from the 6 wheeled 10 ton motor lorry down to the tiny cars that have been put on the road within the last two years, when I tell you that our journey in 1871 along the Great North Road and other English highways was considered such an extraordinary event that our daily progress was recorded in *The Times* and in the best evening paper of those days, the *Pall Mall Gazette* in its earliest form. Most of the time we had reporters of one or other of these papers with us and were amused to read very exaggerated accounts of our adventures the day after they had occurred. Our large omnibus which was constructed to carry 130 people—60 inside, 70 outside—was divided by a curtain so that the front part became a parlour for my wife and her maid and any guests and the back half for engineers and others who joined us for a trip on the road. The top of the omnibus was partly occupied by spares, but, being good natured, we frequently took up considerable parties and transferred them by road from one village to another. We had a good deal of fun out of these visitors. On one occasion running south through a colliery village in Durham quite late in the evening a number of the colliery girls who were just going to bed jumped on the back platform of the omnibus and asked for a ride as we slowed down at their village. Our driver quickened up after we passed the village, and I told the young women that if they did not jump off soon we should be taking them too far away from their homes. They were very lightly clad and I thought they might catch cold. I advised them to step off backwards in the proper way, but, no, they knew better than that; they jumped the reverse way and everyone of them turned somersaults.

As this was a Government business we carried a permit from the Home Office allowing us to use our discretion as to speed. But the County Magistrates did not like this and assembled, held us up on the road. We stopped and the chaff that passed between us and the choleric magistrates was most amusing. One very red-faced gentleman, to whom I said "Good-afternoon" as politely as possible said, "I will have you in prison within a week," and seeing my wife laughing said, " Yes, and that lady too."

At a toll-gate somewhere on the road into Scotland near a place called Wooler, the toll-gate was closed against us. We demanded to be let through free as on Government work. The gateman had closed and locked the gate and said, " Well, you can stay on the road all night." As he spoke, I, who was driving, very gently allowed our train to press against the gate, the gate bent until it left both hinges and lock and flipped away into the adjoining field. The gateman's face was interesting. As this was recorded in *The Times* and the *Pall Mall Gazette*, on our return journey he saw that he had been made a fool of, and the gate was left wide open and he bowed to us most politely.

When we had the train at Wolverhampton at the R.A.S. Show the judges, including the Duke of Devonshire, Sir Frederick Bramwell and many other great swells came on board and asked us to do a bit of manœuvring, turning sharp circles, figures of eight, etc., in an open space. I was driving, I commenced slowly very gradually increasing the speed until we were spinning round figures of eight at nearly 20 miles per hour. We heard shrieks from the inside of the omnibus. I stopped and I regret to say that many of the judges had been sea-sick. The motion of the bus on the huge rubber tyres, far thicker and softer than are now found on any buses, seemed to be very conducive to sea-sickness; there was a gentle swaying boatlike motion which was too much for some stomachs. This *mal de mer* often occurred with this bus.

As far as I can recollect we had very little trouble with horses on the road; we made so little noise, came along quietly. Horses stared at us but were not greatly frightened.

In returning from the North travelling down Dean Street, Newcastle, we experienced the first real bad side slip. The engine with the omnibus measured over 60 ft. in length. It was very greasy and although we were descending the street at a very moderate pace, I found the whole train gradually turning sideways across the street. I tried to straighten it by accelerating the engine; it made matters worse and eventually we slipped sidelong down the whole width of the street, sweeping everything before us, damaging a great number of lamp posts and only straightened up when we got to the level at the bottom. On the Gateshead side we had to mount an incline of about 1 in 12 on granite sets, very greasy and slippery, and when half-way up the train slipped straight backwards to the bottom. We managed eventually to mount the hill by borrowing sacks, which we laid on the street in front of the tyres, and which we picked up and laid down again in rotation, and so we managed to get up the Gateshead incline. At the top we were stopped by a number of men and forcibly taken away. We thought we had done some damage, but no—they, who were foremen and leading hands of various engineering works, had been very impressed by our performance, and they insisted upon standing us a luncheon and drinks. So it may be truly said that on these journeys and on the many hundreds of journeys that followed when these engines were used, during the years from 1871-77, we met with and successfully combated most of the identical troubles that are familiar to every one who now drives his car or motor lorry along our highways.

Following my title, you will perhaps say that you now wish to hear my views as to the present and future of the motor car. You will gather that in the past my recollection and observations are largely personal, but as regards the immediate past I do not think it necessary to say much about the period from the time Sir David Salomons succeeded in getting the Red Flag Act repealed up to the present day other than that the great progress and enormous growth of the automobile industry has been mainly due in these latter years to improvements in the internal combustion engine and to the great development in mass production in America, notably by Ford, which has enabled so many to become motor car owners.

The chief effect of the enormous turn out of low priced small cars has been that all English and American roads are now crowded with car traffic and that the streets of our cities are already overcrowded, so that this traffic question and how to deal with it is the question of the day. For whether the motor car of the future retains its present principal features, or whether it will be superseded by improved cars it is practically certain that now much thought and invention must be applied to the traffic problem.

We are already familiar with Sir Alfred Yarrow's proposal to deal with the difficult question of intersecting traffic by overhead bridges; and with Lord Montagu's suggestion for overhead roadways; but personally I believe we are only now beginning to study the great question of how much can be done by careful training of motor car drivers of all classes to obey and carry out certain traffic rules which, if carefully followed, would allow of far greater circulation and average point-to-point speed in our towns than at present is possible. But this is too large a question for me to go into in this paper, and I think that such traffic regulation would very fitly form a subject of a Royal Society of Arts paper.

Strictly belonging to the traffic problem is that of parking our cars, for without facilities for parking one of the great conveniences of owning a motor car is lost. The available space in our streets and squares is being so rapidly filled up that it is evident that we must devise other means such as have been suggested in the Press. I do not think that the conversion of some of our public squares into huge garages is feasible or desirable. As a mechanical engineer I cannot help thinking that it is not difficult to devise some means to park our cars vertically, that is to say to obtain the cube space necessary for parking up to 200 cars on a ground area of 40 ft. by 40 ft. the total height required of 160 ft. might be disposed 60 ft. below the ground level and 100 ft. above. There are many ways which suggest themselves to the engineer by which this vertical parking could be carried out. I have myself made rough calculations which show that such a vertical garage could be constructed at a cost of £60,000 and would yield a handsome percentage on this capital outlay.

Lastly, I come to the future of the motor car--what shall we see, what form will it take ten years hence ? No one can say that the present car is free from defects; it becomes noisy after wear; it requires the most elaborate precautions and balancing of the reciprocating engine to secure reasonable comfort to the passengers. The motor omnibus and motor waggon offer great room for improvement both as regards riding comfort and reduction of the noise in our streets and of the cost of upkeep. Shall we secure these improvements by improved workmanship and care in the design of parts, or shall we witness an entire revolution in design ? For one thing I believe it will be shown that the use of a rapidly reciprocating internal combustion engine is not conducive to noiselessness, to economy, or to low cost of upkeep. On the other hand, the motor driven electrical vehicles have shown how the even rotation of the electric motor conduces to all three, i.e., comfort of riding, noiselessness and reduced cost. Electrical vehicles using accumulators for storage of power have made gigantic strides during the last few years and it does seem that they are likely to develop as the best means of propelling road vehicles for inter-urban purposes such as omnibus service, delivery of goods by tradesmen, and street scavenging.

A final speculation : is the gas turbine hopeless ? Will it not be possible to store the exploded gases and use them in some form of turbine electrically geared to the wheels of our vehicles ? We have still among us such men of genius as Parsons in this country, and Ljungstrom in Sweden, to whom I offer this vision of the future—the turbine driven motor car, the smooth running noiseless motor car of the future.

DISCUSSION.

THE CHAIRMAN said that Colonel Crompton had covered so much ground that it was difficult to know on which part of his paper to comment. He wished to point out, however, with regard to the lecturer's last suggestion about the question of internal combustion turbine propulsion, that he thought he was right in saying that Sir Charles Parsons, who was an authority on turbines, did not believe in the possibilities of the internal combustion engine in that direction at all. Sir Charles had gone into the problem very thoroughly, and that was his considered view after years of inquiry. Furthermore, although he was not sure what size of vehicle Colonel Crompton had in mind, it was notorious that it was almost impossible to make a steam turbine of any reasonable efficiency unless it was on a large scale. One of the difficulties that Sir Charles Parsons had had in the early days when he started making turbines was that there was no demand for large ones, and it was impossible to get any reasonable efficiency with small ones. By large ones he meant something over 1,000 h.p., and by small, something in the neighbourhood of 10 h.p. Of course, an engine of 1,000 h.p. was a very large engine to put on a motor car; and that was one of the great difficulties that would have to be surmounted if the internal combustion turbine was to be made a practical proposition. He had been very much interested to hear Colonel Crompton's views with regard to the electrical vehicle, because he personally had been under the impression that it was more or less moribund. As far as London was concerned, one saw that a few firms like Harrods had vehicles which went exceedingly slowly, although very smoothly; and one sometimes saw them being towed home. That, at any rate, was his experience of them; but he hardly saw one once a week in London. He understood that in America the electrical vehicle had gone ahead, but he thought the circumstances there must be different. In London he thought there were more electrical vehicles ten years ago than there were to-day. He remembered the first automobile cabs in London, which would be about 20 years ago, were all accumulator-driven cabs, and he remembered similar cabs in Paris, in one of which he had gone from the Moulin Rouge to the boulevard, which was all downhill; the cab went down the hill with a fearful clatter, and on arriving at the bottom the driver had said that none of his brakes would work, and he was not able to stop. That, with about 10 cwt. of accumulators hanging on underneath, was a rather serious matter.

He was sure the meeting had been very much interested in Colonel Crompton's historical reminiscences. What he had said about the solid rubber tyres reminded him of the first journey he had ever taken in a motor car, which was in Scotland. He had had to go to Glasgow to deliver a lecture on Röntgen rays, which would fix the date at about 1897. Lord Blythwood had asked him if he would like to be driven to the station in a motor car; and, as he had never been in one before, he accepted, on being assured that it would get there. About half way to the station one of the tyres had become several yards too long, and he had been afraid of missing his train; but the driver was quite equal to the occasion; evidently that sort of thing occurred every day, because he produced a large jack-knife from his pocket cut a yard or two off the tyre, fixed the ends again, and the car went on as if nothing had happened.

MR. W. WORBY BEAUMONT said he also had been much interested in Colonel Crompton's romance with regard to the motor car and its birth, and its present and its future. A few years ago, as some present at the meeting might remember, he had given first one series of Cantor lectures on road mechanical vehicles, and a few years later another series; and he was sorry to say that the facts he had given in some of those lectures, and also in subsequent papers, did not quite agree with some of those that his genial friend, Colonel Crompton, had given in his paper. He did not like to say that he did not agree with the lecturer in his eulogy of what Thomson did with regard to the motor vehicle of the future; but it was not true to say that the great advance and that the whole of what we know now in the construction of vehicles of that kind had arisen out of the work of Thomson, who made first of all certain kinds of tyres and subsequently some other solid tyres. He himself remembered as a youngster seeing old Mr. Ransome, of the Ipswich Works, riding in his four-wheeled chaise and coming to the works in it, and one heard nothing except the pit-pat of the horse's feet. It was then, of course, a remarkable thing to see a trap running on rubber tyres. Out of Thomson's invention in 1845 there had come a good deal; so much might be said to be true; and a great deal of what Colonel Crompton had mentioned with regard to those Indian steam engines, the "Ravee" and others—one of which he remembered when he was in Ransome's works as an improver—had not been very conspicuously successful. He was sorry to contradict Colonel Crompton, but it was not true to say that the first agricultural traction engine he saw in 1861 was really the first. Agricultural traction engines were made before then. William Worby made one for which the Royal Agricultural Society gave a special medal in 1843, and at the same time it was for the first finishing thrashing-machine. Besides that there were others. One could not put aside all that was done by Ogle and Hancock and Gurney. They only wanted a very little of the help that in subsequent years was obtained, with better materials and better tools and better methods, to have made an absolute success, quite equal to the success that was obtained by others thirty years afterwards. The "Ravee" and those others of the Indian steamers certainly did a very great deal of work; but nobody would now use any one of the particulars, not even including the tyres, which were important in those designs, which were not completely original.

Colonel Crompton had given something from a memorandum attached to the order of the large scale experiment with regard to those engines that were made for India, the three-wheeled engines that pulled the monster bus and so on. He wished to ask Colonel Crompton to say in his reply whether the statements he had given were from memory or whether they were copied from an actual specification.

Colonel Crompton said they were a copy of the Government order.

Mr. Worby Beaumont said there were certain statements there which were not of the order of a specification. Colonel Crompton also said that he now believed that on the day of his first interview with Thomson modern road transport took a great step forward—a step which undoubtedly led to the huge development that had since taken place. His friend the Colonel might be perfectly happy in telling himself to believe that. With regard to those engines he remembered very well some of them, and he thought they were those that came back, which, as Colonel Crompton had said in his history, were made by Ransome, Sims & Head at Ipswich; and anything further from the direction in which improvement, or advance, had taken place than the type of those engines one could hardly imagine. Colonel Crompton said: "On this trip we found that when we ran with bare rubber tyres, which we were able to do in dry weather, the rubber rolled out in front of the driving wheels and actually left the polished steel treads"—of the wheels, he supposed—"so that the engine practically ran on the upper"—would he explain what he meant by running on the upper?—"introduced by the Citroen Company" recently. When that rubber tyre in India ran out ahead like that the vehicle could not be said to be run on the upper; it must have run on the rubber that was on the floor, which was used as a track.

Colonel Crompton said that was what he had said.

Mr. Worby Beaumont, continuing, said that the Colonel stated: "Enough has been said to show that this great experiment was the real precursor of modern road transport, and that if it had not been for the prohibitive legislation that held at the time of the author's return to England in 1875, he was then in a position to do all that has been done since in extending road transport as far as it has been done by the steam motor waggons of the Foden, Burrell, Aveling" and other types and so on. He was sure Colonel Crompton could not have meant to put it quite like that.

Colonel Crompton said he had meant that, and he would explain why in his reply.

Mr. Worby Beaumont said that with regard to the removal of the Red Flag matter, he thought Sir David Salomons would be one of the first to say, "Oh, I took some part in it, but it was not due to me that the Red Flag Order was removed." Interested as he had been with regard to motor vehicles for every one of the purposes to which they were at present put, and especially the internal combustion engine motor vehicles, there was another branch which had been referred to, particularly by the Chairman, namely, the electrical vehicle. There were now in England about 400 charging stations over the country at which those who owned electrical vehicles could go and get either a full or a booster charge, and there was no doubt that for certain purposes—and, curiously enough, that applied more particularly in the heavier work—the electrical vehicle was gradually extending in use. In the earlier days of the passenger motor vehicles the electrical means had been looked to as belonging to the class of light vehicles; but to-day, strangely enough, from a commercial point of view, the satisfactory working of electrical vehicles was in the use of the battery vehicle for heavier work, at which the low speed, not more than about 10 miles an hour, was satisfactory, and heavier work in which the relation between vehicle weight and load weight became gradually more and more satisfactory; also work where the vehicle collecting this or that material used no energy while the operations of collecting and delivering were going on. Vehicles of moderate ton power could run from 25 to 30 miles an hour and deliver at many different places. In all those directions the electrical vehicle had in the last few years made very considerable strides. The difficulty one found was in certain crowded parts of places like London, where the 10 or 12 m.p.h. vehicle was rather in the way, sometimes, of other vehicles which could do from 15 to 20 m.p.h. in traffic; although the rapid acceleration possible with the electrical vehicle was in its favour.

Mr. Thomas Clarkson said he felt it was a great privilege to be permitted to participate in a discussion with such veterans in road transport as Colonel Crompton and Mr. Worby Beaumont. It recalled to mind the first tour in England of motor cars, organised by the Royal Automobile Club (then the Automobile Club) in 1899, when a few cars started from Hyde Park Corner and managed to get to Guildford the first day, the second day to Winchester over the Hog's Back, and thence to Southsea and along the South Coast to Brighton; and throughout that tour those two stalwarts did it on push bikes. The Colonel, he remembered, had on the Hog's Back a push bike with long cranks—$9\frac{3}{16}$—and he used to try that machine; and certainly he (the speaker) could get along with it, as he had long legs; but he would be sorry for short-legged persons on such a machine. A good deal had been done since then by the opening of the new chapter in English automobilism. He had discussed the question of turbines with Sir Charles Parsons, the smaller ones did not interest him very much. The speaker was trying to get people to make small turbines of 400 to 500 h.p. to utilise the steam generated from the waste heat of the internal combustion engine, but nobody seemed sufficiently interested to make them. Sir Charles had said that their efficiency was not high; some people stated that they could produce a turbine of something like 200 h.p. which would yield one brake horse-power for 15 to 16 lbs. of steam per hour and operate practically at atmospheric pressure, the main power being produced by the high vacuum.

In listening to Colonel Crompton's most interesting historical résumé, it was of special note to compare those early runs on the roads, and he (the speaker) had done some of it in 25 years. One forgot many of the interesting experiences, but he did remember on one occasion driving a bus from Chelmsford down to Torquay in October of 1903, the year of great floods. One night on a Devonshire road at about 11.30 on a bright moonlit night, with the moon casting definite shadows slantwise on the road, he misjudged at a cross road the position of the road, and went into the ditch at about 20 miles an hour. The bus heeled over with the two offside wheels in the ditch. Three horses were obtained, but they broke the tackle and ran away, and after two or three attempts the attempt to extricate the bus by means of horses was given up, as the farmers were afraid of their getting injured. By that time a considerable crowd had collected, and he had the idea of utilising the crowd. One man was told off with a chunk of granite to put as a scotch under the wheel on the road, and every half-inch the crowd moved the bus the scotch was placed behind the wheel, and eventually it was got on to the road, little the worse for the experience.

He had been recently concerned in some trials of steam waggons carrying loads of 12 to 14 tons, and doing journeys of 140 miles a day; and that was a rather interesting comparison with those fascinating records of Colonel Crompton's early experiences. He thought it might still be said that notwithstanding the preference which had been shown for, and the money and research which had been devoted to the development of the internal combustion engine, the heavy steam vehicle was still supreme in handling big loads. The internal combustion engine successfully handled loads up to 5 or 6 tons, but beyond that the steamer was doing it all. The transport people said that the load of 12 to 14 tons was the load that paid. He thought some attention might still be given to developing the details of the steam wagon, particularly bearing in mind that it enables one to utilise home-produced fuels instead of an imported fuel.

Mr. L. A. Legros, O.B.E., said he had listened with very great interest to the remarks of Colonel Crompton on the ancient history of road traction as he saw it in England. Every one knew what Colonel Crompton had done in this country with regard to military transport, and that his influence had been very great, though perhaps the actual machines he made did not accomplish very much. Still, the line was right, and he had shown the direction which should be followed; but it required the large weight of manufacture, and above all the goodwill of the military traction people, to see the thing through. Traction to-day in the Army was very different from what it was before the war; but still, there was a very great deal which could be done to put our traction on the footing it should bear in relation to that of other countries. As he had pointed out in an address to the Automobile Engineers, we really want the same sort of development in the War Office as we have in the Admiralty.

Colonel Crompton had alluded to the possibilities of the turbine, and of the internal combustion turbine in particular; and with regard to that there was one class of machine quite outside traction on the ground, i.e., the aeroplane, in which experiments had been performed with a view to improving the running at very great altitudes. The super-charging turbine, which had been described in Paris a couple of years ago, had shown that by the improvements that had taken place in the manufacture of steel, or rather of alloy steels, we now had steels which would stand a very much higher temperature than those which were contemplated when Sir Charles Parsons, he thought, made the remarks referred to. Nowadays, certain steels, instead of resembling lead in their mechanical properties at 700 or 800 deg. F., rather resembled ordinary steel at atmospheric temperature. Steels would now stand the exhaust temperatures of the internal combustion engine; and in France turbines of high efficiency had been made which worked with the exhaust gases of the internal combustion engine, and from the exhaust gas to the internal combustion turbine was a much smaller step than it was from the steam turbine to the exhaust gas turbine. He thought, therefore, that although we were not at present in a position to have an internal combustion turbine-driven car, the day was possibly not very far off when progress in steel and in other materials, and possibly in methods of cooling, would enable an engine of that type to become practical; and the progress in machining and manipulation of materials would enable the thing to be made. But it was easy to look back and think that what one tried to do years ago would have been all right, for it would have been if the conditions of manufacture and the qualities of materials and conditions of all sorts of other things had been only a little bit different from what they were then. The men at that time did their best with what they had Their best was extraordinarily good under those conditions, and it must not be belittled; but, on the other hand, one must not imagine that if one had had the knowledge of to-day one would have certainly got on to the stage in which men were now, because progress had depended on so many lines of improvement all working simultaneously.

Mr. A. E. Parnacott said the author was to be congratulated, at his years, on facing the crowd, as it were, after having faced ridicule and chagrin the whole of his life in new work, in putting forward his views and in prophesying. He (the speaker) had been disappointed in reading the paper to see how little the author had said about the present, and still less about the future, of the motor-car. In view of what Mr. Legros had said about the progress which had been made with metals, he might say that his works had delivered 18,000 piston rings for the Le Rhone engines which were so tough at high temperature that they would spring back to dead shape.

In prophesying the gas turbine of the future the Colonel was probably overlooking two new fields of investigation, namely, the direct production of electricity by the consumption of fuel, and, secondly, the direct conversion, possibly through the thermionic valve of wireless telephony, of those electro-magnetic waves of energy which reach the earth from the sun.

Might he say a little as to the present motor-car, and then, if time permitted, venture some comments as to the future. The present motor-car of British production had an engine so proportioned that it cheated the tax on cylinder bore by excessive piston speed. That so-called horse-power tax had led not to the reduction of tare weight, but to the production of diminutive cars with tiny engines quite unsuited to rough service and overseas generally. The 14,000,000 square miles of British Empire, peopled by no less than 450,000,000 people, was awaiting land transport. Transport was the life-blood of modern interdependence. The present motor vehicles were not suited for other than well-made roads, the mileage of which was relatively infinitesimal. The world war proved that big-engined light vehicles, notably the Ford, were more serviceable than any other vehicle. Reduced tare and more reasonable engine speeds should be encouraged. Personally he believed that the Jowett four-seater, a British production, which weighed only two-thirds of the usual so-called light car, and of the Ford, would continue to increase in demand. He would like to ask the Colonel if he concurred with him in the belief that a tax on the tare weight would go far towards reducing the weight of vehicles, as the present tax had gone far towards reducing the bore of engines.

As to the future vehicle, he felt that if tare weight could be reduced it would be most suitable for overseas, where the mineral and agricultural produce was waiting for good road transport. He had had letters from overseas within the last month on the subject, asking what could be done. He had had in mind that such vehicles should be as far as possible fool-proof. In Africa the natives were not so intelligent as those described by Colonel Crompton. They had no idea of centrifugal force; they would go at the same speed round corners as on the straight, with the result that the vehicles overturned. He thought the vehicle of the future should have about one-third of the present tare weight, which would make it suitable for travelling over roads other than main roads. It should be braked on all four wheels, with four-wheel drive, so as to avoid the stalling on grease or mud.

With regard to rubber tyres, the author had mentioned the very wide band tyres used in the early days, where there was no room for the rubber to move from the centre sideways; it must move in front, and the net result was that the rubber having to move from immediately under the wheel moved forward and caused the looping in front of the tyre—a difficulty which was now got over with the solid band tyres at present in use by reducing the width of the rubber and by vulcanising a special rubber on to the iron band so that the india-rubber proper would remain in position.

Colonel Crompton, in reply, said he had hoped that when Mr. Worby Beaumont spoke he would speak on a subject about which he undoubtedly knew something—namely, electrical vehicles. He was sorry Mr. Beaumont had not been present the previous night, when the room had been crowded with a meeting dealing with the question of electrical vehicles, and where opinion was almost unanimous that they were going to have a great future, both with the trolley vehicle for long stretches of country, road and, for town work, the accumulator vehicle.

As regards some of Mr. Beaumont's criticisms, he had been asked to alter his proof. He would do nothing of the kind. Every word he had put into his paper was either copied from Government documents, or, as regards matters of opinion, expressed opinions which he still firmly held.

He agreed with a great deal of what Mr. Le Gros had said. Undoubtedly progress was largely due to good teamwork and the co-operation of many minds. As to the future, he merely asked the question—whether there was not going to be a great revolution in the use of some form of rotary engine that would have the advantages, which no one knew better than Mr. Beaumont himself, in reducing the running costs to those of electrical vehicles. He had not spoken to Sir Charles Parsons about the turbine, but Sir Dugald Clerk, who had paid very close attention to the matter, told him quite recently that he was hopeful of storing exploding mixtures in reservoirs and from thence taking off a constant supply into some form of turbine or of rapidly rotating engine.

With regard to Mr. Parnacott's remarks as to the reduction of tare weight, that, of course, was what every designer had been at for very many years. He thought Mr. Parnacott had made a very good point as to the width of tyres. Wide tyres were a great mistake, and were one cause of heavy wear in service.

In conclusion he would only say that if his paper had served to vindicate the memory of that great Scotsman who had devoted so much money and so many years of his life to the development of the road vehicle, he should feel satisfied that he had done something useful.

A vote of thanks to the author, which was proposed by the Chairman, was carried unanimously.

MINIATURE OF WILLIAM SHIPLEY, THE FOUNDER OF THE SOCIETY.

Through the kindness of Mr. Herbert Monckton, of Maidstone, the Society has become re-possessed of an admirable miniature of William Shipley, the founder of the Society. The portrait is the work of William Hincks, an Irish painter and engraver, who was born at Waterford, according to Bryan's *Dictionary of Painters and Engravers*, "about the middle of the 18th century. He supplied illustrations for an edition of *Tristram Shandy*, and drew and engraved a series of designs relating to linen manufacture. He came to London, and occasionally exhibited portraits, historical subjects, and miniatures at the Royal Academy from 1781 to 1797."

The following extract relating to the miniature is taken from the Preface to the *Transactions of the Society*, Vol. IV. (1786) :—" The print, which is affixed as a frontispiece to this volume is an exact portrait of the founder of this

Society; the picture from which this print is taken was painted from the life by Mr. Wm. Hincks, who also engraved the copper-plate, and presented them both to the Society, for the purpose of perpetuating the memory and recording the likeness of Mr. William Shipley."

The engraving, which was reproduced in Sir Henry Trueman Wood's *History of the Royal Society of Arts,* differs slightly from the original miniature, as it shows a little more of the figure, and the arrangement of the opening of the waistcoat is not quite the same. The face, however, and the pose of the head are identical in both works.

It will be seen that, according to the extract quoted above, the miniature was presented to the Society by the artist. It is not known exactly how it passed out of the Society's possession. In the latter part of his life Shipley retired to Maidstone, where he was an intimate friend of two bachelors named Peale, who lived in Knightrider House, and their sister-in-law, Mrs. Peale, of Loose, gave the miniature to Miss Monckton in 1866. On the death of this lady, her brother and executor, Mr. Herbert Monckton, found the miniature, and he has generously handed it over to the Society.

A reproduction of the work, which is considered to be a very beautiful specimen of miniature painting, is given at the head of this article.

It may not be out of place to quote the following particulars about William Shipley, which are taken from Sir Henry Trueman Wood's History of the Society (pages 9-11):—

> "Not very much is really known about Shipley's life. He is said to have been born in London in 1714. His father was Jonathan Shipley, 'Citizen and Stationer' of London. He was a native of Leeds, who afterwards lived in Walbrook. William's mother was Martha Davies. Her family owned Twyford House, near Winchester, and the property was inherited by Shipley's brother Jonathan, the Bishop of St. Asaph. He was a liberal-minded divine, and a friend of Franklin. It was said, probably without truth, that he might have been appointed Archbishop of Canterbury but for his strongly-expressed opposition to the American War.
>
> "William Shipley appears to have been an active-minded man, full of ideas, and with some capacity for organisation, but perhaps devoid of ambition, for he never seems to have troubled himself to obtain either credit or profit out of the successful realisation of his ideas. According to a Maidstone tradition he was an absent-minded man, so much so, that on his way to church to be married he was led away by the sight of a rare butterfly to start on its pursuit, and consequently he arrived late for the ceremony. At all events, as soon as the Society he suggested was successfully established and flourishing, he retired from its concerns, though for some four years he seems to have devoted himself energetically and without much pecuniary reward to its establishment. For the

first year after the Society was formed he acted as secretary without pay. When the Society was formally constituted in 1755 he was appointed secretary, and this post was afterwards, in 1757, changed to that of registrar.

"In October, 1760, at a regular meeting of the Society, a letter from Shipley was read, 'acquainting the Society of his having lately engaged in business of such importance as to render him incapable of discharging his duty to the Society as their registrar without very much injuring his own affairs.' What this business was does not appear. It may have been the development of his Academy. At all events, his resignation was accepted, with thanks for his past services. That his retirement was not due to lack of appreciation of those services may be assumed from the fact that he was made a 'perpetual member' of the Society in 1755, was presented with its gold medal in 1756, and had his portrait painted for the Society by Cosway, his former pupil. . . . . .

"It may be that Shipley's capacity lay rather in the direction of origination than of administration. At all events, we hear little more of him in connection with the Society after 1760. He occasionally attended meetings of the Society, and of its committees, and in 1776 he was awarded a silver medal for a life-saving appliance of no great merit. When the date of the Society's jubilee (1804) was approaching, some suggestions were made that this would be a fitting occasion for doing honour to its founder, but his death in 1803 put a stop to all proposals of the sort. In 1768 he went to live at Maidstone, where he was married, and remained until his death in 1803. He was buried in the churchyard of All Saints' Church. All that is known of his life at Maidstone is that he established a local society on the same lines as the Society of Arts, and busied himself in philanthropic work."

Mr. Herbert Monckton (the donor of the miniature) has kindly contributed the following note:—

"William Shipley, long an inhabitant of Maidstone, was originally an artist in London, where he opened a School for teaching drawing. Several of his pupils became eminent as painters, and the example of his school contributed, it is said, to the establishment of the Royal Academy. In 1754, he, conjointly with Lord Romney and several other gentlemen, originated the Society of Arts, and for some time acted as Secretary, and in 1758 the Members presented him with a Gold Medal with the inscription 'To William Shipley whose public spirit gave rise to this Society.' * * There is a handsome monument to him in the North West Corner of All Saints' Churchyard, Maidstone."

NOTES ON BOOKS.

INTERNATIONAL ORTHOTYPE. Part II. By A. Deane Butcher. The Story of Cendrillon, transcribed from the Phonetic Script of M. Paul Passy. London: F. J. Dangerfield. 1*s*. net.

Dr. St. Clair Tisdall, who writes the preface to this little book, remarks: "The system of Orthotype needs only to be known in order to achieve a great success, and to be regarded as one of the most valuable inventions of modern times."

The type has been so fully provided with the same simple geometrical signs, indicating the movements of the vocal organs in speaking French or English, that any beginner who knows his own language is enabled to read the story Cendrillon out loud at the rate of one hundred and twenty words a minute, with M. Passy's own pronunciation, and that without any cumbrous rules, and from the very first lesson.

The system of printing all languages in the same notation is not only an aid to the teacher of large classes, but is a perfectly automatic "Look and Say, Hear and Write" scientific method of self tuition, by the use of which, it is claimed, any commercial traveller will be enabled to sell British goods, with misleading or unpronounceable names, in foreign markets. It is also said to do away with the serious handicap from which all English-speaking people suffer, by reason of their own faulty education and unscientific antiquated print.

ANCIENT EGYPTIAN WORKS OF ART. By Arthur Weigall. London: T. Fisher Unwin. £3 3*s*.

Our conception of Egyptian art has, no doubt, suffered much from the fact that what is left of it is generally exhibited to very poor advantage. Egyptian relics are for the most part regarded as curios rather than objects of art, and thus, even in such places as the British Museum, they are treated rather as historical and archæological facts than as artistic treasures. This point of view has led to the indiscriminate herding together of all kinds of pieces, greatly to the detriment of those that possess real artistic beauty, for they are mixed up higgledy-piggledy with masses of things whose chief claim to interest lies in their great age and the light that they may throw on early civilisations. It is Mr. Weigall's object in this volume to extract the artistic gold from the dross, and "to bring to the notice of persons interested in art a series of Egyptian antiquities which will show the artists of the Pharaohs at their best."

The period dealt with extends from the beginning of dynastic history in Egypt, about 3500 B.C., to the first century of the Roman occupation, and this is divided up into twenty sections. The author contributes a brief note on each section, which is followed by photographs of works characteristic of the age. In all there are some five hundred illustrations representing statues, busts, paintings, reliefs, jewellery, etc. A study of these—even a cursory perusal—leaves one with two prevailing impressions: the first is wonder at the quality of some of the earliest work, executed over five thousand years ago; the second is a full and frank acknowledgment of the very high level of artistic merit produced by the best workers throughout the whole period covered.

The subjects for illustration have been selected with admirable taste, and one would like to draw special attention to many of the pictures were it not that comment on them would be rather meaningless unless they were reproduced here. In spite of this objection, however, one cannot refrain from expressing admiration for the picture of the doorway in the Temple of Dendur on page 352. " In all Egypt," writes Mr. Weigall, " there is not a more beautiful doorway." The delicacy, the harmony and the dignity of the ornament would be hard to beat in any country.

From what has been written above it will be seen that Mr. Weigall views his subject from a somewhat new angle. His lifelong experience as a field explorer and as Inspector-General of Antiquities to the Egyptian Government, and the numerous works which he has already published, are sufficient guarantee of his high standing as an archæologist; but in emphasising the artistic side of the work he has succeeded in giving a most convincing proof of the very high level attained by Egyptian artists, sculptors and craftsmen. Another point about the book is that it will appeal to the layman no less than to the Egyptologist: if the latter may taste an added professional joy in disputing some of the dates suggested by Mr. Weigall, any one with a modicum of artistic perception will find page after page to rouse his interest and admiration.

A word of praise must be given to the publishers and printers of this volume for the excellent way in which the illustrations have been reproduced

COTTON GROWING IN COLOMBIA.

The following note on Colombian cotton as grown in the Departments of Atlantico and Magdalena is taken from the recent report of His Majesty's Consul at Barranquilla:—

The Gossypium Arboreum, or tree cotton, is sown in April or August, according to rains and local conditions. Picking takes place during March and April.

An average cotton plant has a life of six to seven years; after that date the plant is rooted up and new seeds sown

There are approximately 1,500 trees of seed cotton per hectare, and the average production per tree is ½ lb., which gives 30 arrobas per hectare of seed cotton, or 240 lbs. of ginned cotton. The latter figure is approximate only, as figures as low as 14 arrobas per hectare and as high as 65 arrobas per hectare are recorded, all depending on the amount of rain between April and October.

After the first year's crop the cotton trees are pruned down to within 24 inches of the ground (an average tree grows to about 8 feet high) for two consecutive years, and the third year the tree is cut down to ground level, generally after the first rains.

Trouble has been caused by *guzanillo*, which destroy completely the cotton plant by devouring it. These caterpillars only make themselves present in the very dry season, and are destroyed by the application of Paris green. It is calculated that the total production of the Departments mentioned above will not exceed 250,000 arrobas this year (1924), it being calculated that there are approximately 8,500 hectares under cultivation.

Certain cotton planters have recently been studying irrigation for the plantations, and it is calculated that a production of 60 to 70 arrobas per hectare can readily be produced with irrigation.

THE IRON ORE DEPOSITS OF SWEDEN.

The Swedish deposits of iron ore occur mainly in two distinct regions, viz., Central Sweden and in Lapland. The first-named region comprises an area of about 15,000 square kilometres, within which are found the well-known ore deposits of Dannemora and Grängesberg. The Lapland iron ore deposits are mainly situated to the north of the Arctic Circle, between 67° and 68° north latitude and between

19° and 22° east longitude, Greenwich. Within this district, which has an area of about 8,000 square kilometres, are to be found the largest deposits of ore iron in Sweden, viz., Kirunavara and Gellivare, from which large quantities have been exported during the last few decades. In virtue of a former resolution passed by the Riksdag, investigations have been in progress during the past 10 years for the purpose of arriving at an approximate calculation of the available iron ore deposits. In this connexion, writes the Commercial Secretary to H.M. Legation at Stockholm, in his annual report, very important reports were submitted by the experts during 1923, according to which the total deposits in the northern ore fields are estimated at no less than 1,500,000,000 tons, and those in Central Sweden at 260,000,000 tons, providing the latter are worked to a depth of 200 metres. Borings carried out to a depth of 960 metres below the surface at Kirunavara have shown that the ore body continues to this depth, and is of great thickness and purity. It is, therefore, calculated that the quantity of ore available at this mine is far in excess of the 740,000,000 tons estimated in 1913, when the limit of the ore body was assumed to be 300 metres below the surface. An analysis of the samples from these borings shows that the quality has been found to be superior at greater depths than nearer the surface, inasmuch as the proportion of first grade ore, with a low content of phosphorus, is much greater, rising from 30 per cent. in the existing workings to 60 to 70 per cent. at a greater depth.

MEETINGS OF THE SOCIETY.

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ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock, unless otherwise announced:—

NOVEMBER 26.—C. F. ELWELL B.A., "Talking Motion Pictures." ALAN A. CAMPBELL SWINTON, F.R.S., will preside.

DECEMBER 3.—PROFESSOR C. A. CARUS-WILSON, M.A., F.R.A.S., "The Teaching of Science in Secondary Schools." SIR ROBERT ABBOTT HADFIELD, Bt., D.Sc., F.R.S., will preside.

DECEMBER 10. (5.0 p.m.).—NORMAN THOMSON, "Colombia as a Field for Development." THOMAS J. IVE, Vice-President of the Anglo-Colombian Chamber of Commerce, will preside.

THURSDAY, DECEMBER 11.—Senatore Guglielmo Marconi, G.C.V.O., LL.D., D.Sc., Chairman's Inaugural Address.

INDIAN SECTION.

Friday Afternoon at 4.30 o'clock:—

DECEMBER 5.—LIEUT.-COLONEL R. MCCARRISON, C.I.E., M.D., LL.D., D.Sc., F.R.C.P., Indian Medical Service, "Problems of Food, with Special Reference to India." PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., will preside.

PAPERS TO BE READ AFTER CHRISTMAS.

SIR ERNEST RUTHERFORD, M.A., D.Sc., F.R.S., *Trueman Wood Lecture.*

SIR J. FORTESCUE FLANNERY, Bt., Past-President of the Institute of Marine Engineers, "The Diesel Engine in Navigation." LORD BEARSTED will preside.

SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., "The Power of Internal Combustion Engines for Motor Cars."

MAJOR-GENERAL SIR WILLIAM SEFTON BRANCKER, K.C.B., Director of Civil Aviation, Air Ministry, "Commercial Aviation."

HENRY G. DOWLING, "Wallpapers."

CLAUDE H. FRIESE-GREENE, "Colour Film Processes."

J. S. OWENS, M.D., A.M.I.C.E., F.G.S., Superintendent Advisory Committee on Atmospheric Pollution, Air Ministry, Meteorological Office, "Modern Atmospheric Conditions."

SIR SAMUEL INSTONE, "The Thames Passenger Services."

CEDRIC CHIVERS, "Bookbinding."

PROFESSOR W. E. S. TURNER, O.B.E., D.Sc., F.Inst.P., Department of Glass Technology, University of Sheffield, "The Modern Production of Sheet-glass."

C. R. PEERS, C.B.E., F.S.A., Chief Inspector of Ancient Monuments and Historic Buildings. Subject to be announced later.

LIEUT.-COLONEL ANDREW BALFOUR, C.B., C.M.G., M.D. (Edin.), B.Sc., D.P.H., F.R.C.P.E., "The Trend of Modern Hygiene."

MRS. GRAYDON-STANNUS, "Irish Glass, Old and New."

CHARLES A. BAKER, Engineering Department, London County Council, "The Electrical Equipment of the London County Hall."

EMILE CAMMAERTS, "The Restoration of Public Buildings in Belgium."

LIEUT.-COLONEL SIR DAVID PRAIN, I.M.S., C.M.G., C.I.E., M.A., LL.D., F.R.S.E., F.R.S., *Sir George Birdwood Memorial Lecture*, "Government Botanical Gardens."

J. T. MARTEN, M.A., I.C.S., "The Indian Census."

SIR HENRY SHARP, C.S.I., C.I.E., M.A., "The Development of Indian Universities."

SIR GILBERT T. WALKER, C.S.I., M.A., F.R.A.S., Sc.D., Ph.D., F.R.S., "Indian Meteorology."

BRIGADIER-GENERAL SIR PERCY M. SYKES, K.C.I.E., C.B., C.M.G., "The Heart of Asia and the Roof of the World."

SIR ALFRED CHATTERTON, C.I.E., Assoc.M.Inst.C.E. Subject to be announced later.

LORD STEVENSON, G.C.M.G., "The British Empire Exhibition, 1924."

HON. WILLIAM G. A. ORMSBY-GORE, M.P. Subject to be announced later.

LORD BLYTH, "Penny Postage and Postal Communications Generally."

CANTOR LECTURES.

Monday evenings, at 8 o'clock.

LOUIS C. MARTIN, D.I.C., A.R.C.S., D.Sc., Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and

Technology, South Kensington, " Modern Colour Problems." Three Lectures. November 24, December 1 and 8.

LECTURE I.—The relations of light and colour. The physical basis of colour vision. The production of artificial daylight. Early efforts and modern improvements. The application of artificial daylight for time saving in industry.

LECTURE II.—The psycho-physical basis of colour measurement. Specification of colour in terms of three variables. Colour systems and charts. Definite problems in colour measurement and their importance in Commerce.

LECTURE III.—Colours of material objects. Some colorimeters and their possible accuracy. Limited range colorimeters and nephelometers. General lines of progress. Probable limitations of these methods.

V. E. PULLEN, Director, Radiological Research Department, Woolwich, " Radiological Research—A History." Three Lectures. January 19, 26, February 2.

LECTURE I.—Natural Philosophy. The Fascination of speculative philosophy. The border line between science and philosophy. Early natural philosophy. Development of theory. Discovery of X-rays. Controversy as to their nature. Modern theory concerning X-rays. Relation to modern atomic theory.

LECTURE II.—Early apparatus. Early X-ray generators. Early vacuum tubes. X-ray tubes. Development of electrical generators. Development of X-ray tubes. The X-ray spectrometer. Measuring apparatus. Lines of modern radiological research.

LECTURE III.—Early applications of X-rays. Development of medical uses. Modern applications. Physiological dangers. Necessity for protection.

WALTER ROSENHAIN, B.A., B.C.E., D.Sc., F.R.S., Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory, " The Inner Structure of Alloys." Three Lectures. February 16, 23, March 2.

HOWARD LECTURES.

PROFESSOR JOHN SAMUEL STRAFFORD BRAME, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, " Motor Fuels." Three Lectures. April 20, 27, May 4.

DR. MANN JUVENILE LECTURES.

Wednesday afternoons, at 3 o'clock.

LIEUT.-COLONEL G. M. RICHARDSON. Two Lectures.

LECTURE I.—January 7.—" Dogs in War."
LECTURE II.—January 14.—" Dogs in Peace."

(Special tickets are required for the Dr. Mann Juvenile Lectures.)

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

Monday, November 24..Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Sir George Foster, "Links of Empire."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 7 p.m. (Informal Meeting.) Discussion on "The Electrostatic Wattmeter used for Measuring Dielectric Losses in Cables."

Victoria League, 22, Eccleston Square, S.W. 5 p.m. Sir Thomas W. Arnold, "The Prophets of Islam in Art."

Architectural Association, 34, Bedford Square, W.C. 8 p.m. Mr. E. J. T. Lutyens, "A.A. Excursion in Spain."

University of London, King's College, Strand, W.C. 5.30 p.m. Prof. B. O. E. Ekwall, "English Place Names." (Lecture II.).

5.30 p.m. Dr. R. W. Seton-Watson, "Austria-Hungary, 1867-1918." (Lecture VIII.)

People's League of Health, at the Medical Society, 11, Chandos Street, W. 6 p.m. Sir Frederick Mott, "Mind and Body."

Tuesday, November 25..Anthropological Institute, at the Royal Society, Burlington House, Piccadilly, W. 8.30 p.m. Prof. Dr. Réné Verneau, "La Race de Neanderthal et la race de Grimaldi: leur role dans l'Humanité. (Huxley Memorial Lecture.)

Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Mr. D. L. Thornton, "The Role of Technical Training in Marine Engineering."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. F. R. Newens, "With Camera and Colour Plate."

University of London, King's College, Strand, W.C. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia from 1861." (Lecture VIII.)

5.30 p.m. Miss Hilda D. Oakley, "The Philosophy of the Absolute in English Thought." (Lecture II.)

Wednesday, November 26..Microscopical Society, 20, Hanover Square, W. 8 p.m. (Industrial Applications Section.) Joint Meeting with the Institution of Structural Engineers. (1) Discussion on the Microscope in the Portland Cement Industry. (2) Mr. J. E. Barnard, "Self-Luminous Objects."

University of London, University College, Gower Street, W.C. 5.30 p.m. Mr. A. Esdaile, "The British Museum Library: II. The Collections."

At the Royal Academy of Music, Marylebone Road, N.W. 3 p.m. Lecture by Mr. P. A. Scholes.

At King's College, Strand, W.C. 5.30 p.m. Prof. B. O. E. Ekwall, "English Place Names." Lecture III.)

Public Health, Royal Institute of, 37, Russell Square, W.C. 4 p.m. Prof. Winifred Cullis, "The Practice of Health."

Chadwick Public Lecture, at the Medical Society, 11, Chandos Street, W. 5.15 p.m. Dr. W. M. Feldman, "Ante-Natal Child Physiology and Hygiene."

China Society, School of Oriental Studies, Finsbury Circus, E.C. 5 p.m. Lt.-Col. E. F. Strange, "Chinese Lacquer."

Thursday, November 27..Massage and Medical Gymnastics, Chartered Society of, at the Royal Society of Arts, John Street, Adelphi, W.C. 6 p.m. Lecture by Dr. W. T. G. Pugh.

Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p.m.

Textile Institute, 38, Bloomsbury Square, W.C. 5.45 p.m. (Informal Meeting.) Mr. D. Anthony-Lansdale, "Waterproofing of Fabrics."

Aeronautical Society, 7, Albemarle Street, W. 5.30 p.m. Dr. G. C. Simpson, "Thunderstorms."

Child Study Society, 90, Buckingham Palace Road, S.W. 6 p.m. Dr. J. J. Findlay, "Education and Rhythm."

Mechanical Engineers, Institution of (Glasgow and West of Scotland Section). Royal Technical College, Glasgow. 7.30 p.m. Joint Meeting with the Institution of Locomotive Engineers. Signor Caprotti, "A New Valve-Gear for Locomotives."

London County Council, at the Geffrye Museum, Kingsland Road, E. 7.30 p.m. Prof. I. Beaumont, "Italian Furniture and Decoration."

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. E. G. Gardner, "The Personality of Mazzini."

5.30 p.m. Prof. P. Geyl, "William III. as Stadholder." (Lecture I.)

At King's College, Strand, W.C. 5.15 p.m. Prof. J. A. K. Thomson, "The Social and Political Ideas of some Great Thinkers of the Renaissance and Reformation." (Lecture VI.) "Disiderius Erasmus."

5.30 p.m. Senor O. V. Salomon, "Peru, Old and New." (Lecture II.)

5.30 p.m. Prince D. S. Mirsky, "The Russian Novel from Turgenev to Chekhov." (Lecture VIII.)

At the Bedford College for Women, Regent's Park, N.W. 5.15 p.m. Prof W. N. Jones, "Dual Personality in Plants."

Friday, November 28..Meteorological Society, Joint Meeting with the Physical Society, at the Imperial College of Science and Technology, Imperial Institute Road, South Kensington, S.W. 5 p.m. Discussion on "Ionization in the Atmosphere; the Influence on the Propagation of Wireless Signals." (1) Dr. W. H. Eccles, Opening Address. (2) Dr. C. Chree, "Atmospheric Ionization and its Variations." (3) Prof. E. V. Appleton, "Experimental Observations of the Strength of Wireless Signals as affected by the Path of the Signals, time of day and season of year." (4) Mr. R. A. W. Watt, "Atmospherics." (5) Prof. C. T. R. Wilson, "The Electric Field of a Thunderstorm and some of its Effects." (6) Prof. S. Chapman, "The Evidence of Terrestrial Magnetism for the Existence of Ionized Layers in the Upper Atmosphere."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 7 p.m. (Informal Meeting.) Mr. G. L. Ponsford, "Centrifugal and Rotary Pumps."

(Yorkshire Branch.) Sheffield. 7.30 p.m. Prof. F. C. Lea, "The Effect of Repetition Stresses on Steels."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Capt. C. W. R. Knight, "Bird Life from an Observation Post."

University of London, King's College, Strand, W.C. 5.30 p.m. Dr. O. Vocadlo, "Three Champions of Bohemian Reformation." (Lecture IV.)

5.30 p.m. Prof. E. W. MacBride, "Scientific Method."

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FRIDAY, NOVEMBER 28, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, DECEMBER 1st, at 8 p.m. (Cantor Lecture.) LOUIS C. MARTIN, D.I.C., A.R.C.S., D.Sc., Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and Technology, South Kensington, "Modern Colour Problems." (Lecture II.)

WEDNESDAY, DECEMBER 3rd, at 8 p.m. (Ordinary Meeting.) PROFESSOR C. A. CARUS-WILSON, M.A., F.R.A.S., "The Teaching of Science in Secondary Schools." SIR ROBERT ABBOTT HADFIELD, Bt., D.Sc., D.Met., F.R.S., will preside.

FRIDAY, DECEMBER 5th, at 4.30 p.m. (Indian Section.) LIEUT.-COLONEL R. MCCARRISON, C.I.E., M.D., LL.D., D.Sc., F.R.C.P., Indian Medical Service, "Problems of Food, with Special Reference to India." PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., will preside. Tea and coffee in the Library at 4 o'clock.

CHAIRMAN'S INAUGURAL ADDRESS.

The Chairman's Inaugural Address, which had to be postponed owing to the unavoidable absence abroad of Senatore Guglielmo Marconi, G.C.V.O., LL.D., D.Sc., will be delivered on Thursday, December 11th, at 8 p.m, the subject being "Radio Communications."

The Swiney Prize and the medals awarded for papers read during the past session will be presented.

Tea and coffee will be served in the Library after the meeting.

DOMINIONS AND COLONIES AND INDIAN SECTIONS. (JOINT MEETING.)

The paper by Lord Stevenson, G.C.M.G., on "The British Empire Exhibition," has been unavoidably postponed to January 19th.

DR. MANN JUVENILE LECTURES.

Under the Dr. Mann Trust a short course of lectures adapted to a juvenile audience will be delivered on Wednesday afternoons, 7th and 14th January, 1925, at 3 p.m., by LIEUT.-COLONEL E. H. RICHARDSON, on "Dogs in War" and "Dogs in Peace." The lectures will be fully illustrated with lantern slides, and by the dogs themselves.

Special tickets are required for this set of lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to tickets admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "A Study of the Destructive Distillation of Coal," by Edward Victor Evans, O.B.E., F.I.C., Chief Chemist and Products Manager, South Metropolitan Gas Company, have been reprinted from the *Journal*, and the pamphlet (price 2s.) can be obtained from the Secretary, Royal Society of Arts, John Street, Adelphi, W.C.

A full list of lectures which have been published separately and are still on sale can also be obtained on application.

PROCEEDINGS OF THE SOCIETY.

SECOND ORDINARY MEETING.

WEDNESDAY, NOVEMBER 19TH, 1924.

MR. EDWARD BROWN, F.L.S., President of the International Association of Poultry Instructors and Investigators, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Bahri, Hakim Roy, B.Com.; Delhi, India.
Barton, Sir William, J.P., Stockport.
Burrell, William Gunn, M.A., Glasgow.

Clinton, William Wills, London.
Fairey, C. R., M.B.E., F.R.Ae.S., Hayes, Middlesex.
Horning, Harry Le-Van, Waukesha, Wisconsin, U.S.A.
Minns, Miss Susan, Boston, U.S.A.
Pountney, Harold W., London.
Rothwell, Charles Frederick Seymour, Radlett, Herts.

THE CHAIRMAN, in introducing the reader of the paper, referred to an article he (the speaker) recently found in the transactions of the Royal Society of Arts for 1864 bearing on the subject to be discussed. It was interesting to know that 60 years ago that great Society was paying attention to the matter in the midst of its manifold activities. He did not know whether the Society had since done much in the same direction; if not they were coming to a re-birth, which was always a satisfactory thing. All engaged in the poultry interest would appreciate the Society's invitation to Mr. Atkinson to read a paper.

Artificial incubation had made marvellous progress during the last sixty years. He could not go back so far as that, but forty-nine years ago he had operated his first incubator. That was the old Boyle incubator, which cost £25 and held 24 eggs. As one cast one's mind back, one could recall a host of different classes of machines and of different theories in respect to artificial hatching, and also as regards rearing. In days gone by all the progress was made by practical men. The industry was not big enough for the scientific men; they did not pay much attention to it. But now, instead of being a mere side-issue, the poultry industry was one of the great factors of human endeavour in almost every part of the world, and scientific men were beginning to look at it. The industry welcomed them, because they could make a contribution which was impossible to those who had been denied scientific training. A few days previously he had had a short chat with the lecturer, who had given expression to what, no doubt, all those present had often thought—that as in other matters of that kind—one could only judge the incubator by what it did, and not by what it looked like. If Mr. Atkinson could help them to avoid some of the pitfalls which with extended operations seemed to increase rather than diminish, he would have rendered a great service, and poultrymen would welcome his co-operation.

The paper read was:—

THE SCIENTIFIC PRINCIPLES OF ARTIFICIAL INCUBATION.

By LLEWELYN B. ATKINSON, M.I.E.E.,
Past-President of the Institution of Electrical Engineers.

INTRODUCTION.

The literature of artificial incubation is hardly worthy of the extensive industries which are based upon the art, and is spread through a great quantity of papers, reports and journal articles. Moreover the uncertainties surrounding the operations of incubators and the theories and discussions among those working incubators are often so empirical that it seems time some attempt were made to reduce the whole question from an art to a science. Science, the late Lord

Kelvin declared, is measurement, and as soon as we can reduce a subject to exact measurement and can thereby reproduce effects with certainty so soon can we claim to have reduced it to a science.

Having for some 15 years practiced artificial incubation in connexion with the rearing of poultry as a hobby, and having suffered from all those uncertainties above referred to, and having over the last year or two made a great variety of measurements and observations on the performance of different types of incubators, I think it may be of interest to record these observations and measurements, and to connect them by the general theory of the questions involved. The final object of such observations and measurements is to permit an incubator to be designed on paper and worked in practice which shall give a perfectly definite result as a hatching machine. The incubator which will do all the best hen can do, and do it regularly and with certainty, is, in my opinion, a perfectly realisable instrument.

To those who have superficially examined the hatching of a hen's egg, and the simplicity of the apparatus used, it seems difficult to believe that there is any reason why eggs should not be easily hatched apart from the hen.

The eggs are put in a nest, a rough dish or receptacle made of almost anything, and kept warm for a certain time and the eggs hatched. Simplicity itself. Moreover for thousands of years the hen has, in certain countries of the East, been replaced by artificial methods of hatching as in the case of the Egyptian and Chinese hatching ovens, or the Malay method of hatching in fermenting vegetable matter or in barrels by the sun's heat. So it is curious that among Western people the problem has only been solved at all within recent years, and really only in a way at all final as late as 1882 when Hearson produced his incubator with capsule temperature regulator.

Since then both in Europe and in America, particularly the latter, a great number of different makes of incubators of all kinds have been developed, and whilst nearly every one of these does at times produce good results, yet to-day it is probably true that there is an all-round hatching efficiency not greatly exceeding 55% of fertile eggs, though there are plenty of hatches in well managed incubators with "strongly fertilised" eggs (whatever that may mean) up to 85% and 90%.

It is particularly this latter fact that led me to ask myself the question, why is it that at times results equal to that produced by a hen can be achieved, and yet with far more delicate arrangements than a hen provides in the way of container (nest), shelter, and the like, we cannot always with certainty equal her results. The problem thus stated at least seemed one to which an answer could be given. If it depends on personal attention and manipulation of individual eggs by the hen, then it may be beyond achievement as a practical result—but this idea seemed negatived by the fact above quoted that undoubtedly artificial hatching is at times equal to the hatching by any hen.

Of the studies I have made and the results obtained this paper is an epitome.

BRIEF HISTORICAL SURVEY.

For many centuries it has been the practice both in China and Egypt to hatch chicks in incubators.

The methods of these two countries have features in common though they differ in details.

Taking first the Chinese method, I am indebted to Professor King, of Wisconsin University, U.S.A., for an interesting description to be found in his fascinating work on Chinese agriculture entitled "Farmers of 40 Centuries." In this book is described his visit to a Chinese incubating establishment which was capable of dealing with 36,000 eggs at one time. I have to thank Mrs. King for permission to quote from this work.

The incubator building is in the village street and contains 30 incubators each consisting of a large earthenware pot surrounded and heat-insulated by basket-work with an opening cut in one side underneath where a charcoal fire can be introduced. The eggs are placed to a number of about 600 in a basket placed within another jar nearly of the same size, this being placed inside the first earthenware jar or container, the whole being warmed from below by the burning charcoal. At regular intervals the basket is removed and the mass of eggs turned over. At the tenth day the eggs are taken out of the basket and the surrounding jar and placed in trays on a shelf above the incubators and covered with blankets or cloths, relying on the general warmth of the atmosphere above the incubator together with the heat produced by the egg itself for maintaining the temperature. The temperature is regulated entirely by skill in feeling the temperature of the eggs, being adjusted at the first stage by manipulating the charcoal fire, and at the second stage by putting on or off the blankets which lie above the trays.

Professor King states that with this apparently crude method 95% to 98% of fertile eggs are hatched, infertile eggs varying from 5 to 25%.

The Egyptian incubators also consist of extensive buildings. I am indebted to Capt. Cadman, who has recently returned home from a post in the Egyptian Department of Agriculture, for many interesting details and experiments which he has made with these incubators. Some of these particulars were published by Capt. Cadman at the Poultry Conference held at the Harper Adams College in August, 1923, and the slides shown are partly reproductions from the drawings which he then published, and partly slides which he has kindly lent me.

The process in these incubators briefly is as follows:—

A building is divided into separate chambers or ovens. Each chamber will accommodate about 7,000 to 8,000 eggs and is divided into upper and lower parts. The lower part starting on the floor is where the eggs are first placed in heaps and above this, forming, as it were, the floor of the upper part, are trays which are filled with the fuel to be used consisting of a mixture of dry straw and camel dung which being lighted burns slowly and gives off a steady heat. This partly heats the overhanging dome, which reflects heat to the floor, and partly radiates heat directly on to the eggs. For the first 10 days the heaps of eggs are moved every six hours, being turned in so doing, and on the tenth day the fires are extinguished and the eggs spread out in layers partly on the floor where they have been and partly on the trays which, up to this time, have carried the fuel. From this time onwards they rely for heat upon that already stored in the brickwork and that produced in the vital process of the egg itself.

Capt. Cadman states that by this method from 85% to 90% of the fertile eggs are hatched. Great importance is attached by incubator workers to constantly turning the eggs, which is done four times daily.

Capt. Cadman has obtained by automatic recording thermometers and hygrometers, and by taking samples of the air of these incubators, complete information as to the temperature, moisture and carbonic acid, and these will be referred to later.

At the last census in Egypt there were 28 of these incubating establishments, hatching between them about 42 million eggs annually.

It is a long jump from these ancient methods to the modern incubator, and it would be hardly worth while sketching the early attempts that were made in Western Europe and America to produce a suitable machine.

The first machine which really seems to have solved the problem of a workable invention was that made by Charles Hearson, in 1882, the fundamental element of which consisted in the provision of a very simple, but accurate, regulator, almost universally used to-day, and known as the Capsule Regulator, which will be referred to later, together with an appropriate arrangement of a hot tank heating the upper surface of the eggs and a supply of air (suitably moistened by passing over a moist cloth) rising up through the eggs from below.

Many different makes of incubators have since appeared with minor improvements and additions, but this fundamental type remains as one of the principal types used, and for simplicity may be called the "Tank Machine."

The tank itself may be filled and heated by hot water or by hot air, or it may be replaced by a plate or grid of wires heated by electric current. The principle remains the same.

The action consists in heating the upper surface of the eggs by radiation from the tank, and the surface of the eggs thus heated warms the air lying between the tank and the eggs. It is not the case, as is often supposed, that the air is heated by the tank and that the air warms the eggs.

The next type of modern incubator is that known as the "Hot Air Machine." In this type there is a chamber above the eggs, the bottom of which is formed of flannel or canvas, which will permit the passage of air to the eggs placed below on a tray, and through them to the outlets. Hot air is supplied to the top chamber from a heated vertical chimney outside the incubator, and flows downwards through the diaphragm, through the eggs, and out at the bottom of the egg chamber. In this case the eggs are heated by direct supply to them of hot air.

A type which is very like the second one described is that in which the air in the incubator, being heated by pipes or otherwise, is circulated round and through the eggs by fans, and in which the same air is circulated over and over again, with a comparatively small admission of fresh air, and a comparatively small escape of consumed air. With great variety in detail, practically all existing types of incubators fall within these three categories; the differences in their action will appear later.

Before considering further in detail the action of these types, it is necessary to consider questions of physical science, which are involved in the operations of incubators.

Ideas among makers of incubators on some of these questions are vague, and by some they are ignored. They will be considered under the following headings:—

1. Heat production.
2. Heat transfer.
3. Air and gas movement.
4. Humidity and evaporation.

HEAT AND HEAT PRODUCTION.

In all heat problems there are two questions involved, one is the *temperature* or degree of intensity of the heat, measured by a thermometer, the other is the *quantity* of heat, which is a quantity of energy, and may be the energy of the sun, or produced by the combustion of coal or oil, or from water power by production of electric currents and their utilisation, or in other ways, and is measured by the quantity of a substance which will have its temperature raised a definite amount by the quantity of heat.

If a pound of water, or of iron, or of air at any given temperature were placed in an enclosed space at a higher temperature than itself, it would soon reach the same temperature as the enclosed space, but the quantity of heat necessary to change the temperature one degree would be very different.

We take as our unit, as is usual in this country, the quantity of heat which would be required to raise the temperature of a pound of water one degree on the Fahrenheit scale, and calling this one British thermal unit, we may compare this quantity with that required to raise the temperature of one pound of other substances by one degree Fahrenheit, as given in the following table.

Table of Specific Heats or Heats Required to Raise 1lb. of a Substance 1°F.

Substance.	*Specific Heat.*
Water	1.000
Alcohol	.622
Ether	.477
Glass	.198
Brick	.185
Iron (wrought)	.114

Copper	.095
Wood (mean)	.565
Air (constant pressure)	.238
Carbonic Acid	.216
Water Vapour	.475

HEAT PRODUCTION.

For our purpose in connexion with incubators there are practically only two methods of heat production that need be considered.

First is the method of combustion of fuel, and all that need be noted here is that different substances being burnt in air evolve different quantities of heat, and require different quantities of air, as is shown in the following table :—

Table of Heat Produced by Combustion of 1lb. of Substance, and Minimum Quantity of Air Required.

Combustible.	*Heat Produced. British Thermal (BTU).*	*Cubic feet of air units required at 62° F. theoretical.*
Coal (bituminous) mean value ...	14,112	147
Coke	8,000	135
Paraffin Oil	19,800	186
Alcohol	12,340	120
Coal Gas	21,400	180

At least twice this quantity of air will be required to effect complete combustion.

In every case the product of the burning is carbonic acid gas from the carbon of the fuel, and of water vapour from the hydrogen of the fuel.

The heated gases thus produced are considered unsuitable for introduction directly into contact with the eggs in incubators of modern type, though it has to be noted that in the Chinese and Egyptian incubators the products of combustion of the fuel are produced in the chamber where the eggs are placed, but in this case, of course, there is a substantial admission of air to moderate the fuel temperature, and to dilute these products of combustion. In modern incubators, however, the direct heat of hot gases produced by combustion is used to heat water in a water tank machine, or introduced into the hot air tank of a hot air tank machine, or used to heat a separate supply of air to be passed through a hot air machine.

Secondly is the method of introducing heat into an incubator by means of electrically heated wires, the source of heat in this case being either the heat of fuel burnt at an Electric Generating Station, or the heat of the sun which has evaporated and lifted water, which again condensing and going down waterfalls has operated electric generators in hydraulic electric stations.

One kilowatt hour, that is, one unit of electricity, is equivalent to or produces 3,430 British thermal units.

HEAT TRANSFER.

If we place one end of a copper rod in a flame or fire, we shall very soon find that at some distance from the fire the rod becomes hot. If we do the same with a rod of wood, we shall find that one end in the heat is burnt up and destroyed, whilst the other end remains cool. In the first case the metal rod acts as a conductor and is a good conductor of heat, and the heat is said to be *conducted*; in the second case, although in fact the heat is also conducted along the wooden rod, the conduction is so slow that the heated end is not sufficiently cooled to prevent it being destroyed. It is a bad conductor. If we place a vessel of water on the fire, the heat enters the bottom and soon the whole of the water including the top is hot. It seems as if the water had *conducted* the heat, and was a good conductor. But reverse the process. By means of a gas burner playing on the top of the vessel or even the water, apply heat to the top. It will heat up and give off steam, but the bottom of the water will remain cool. It seems as if water will conduct heat upwards and not downwards. But this is not the case. The explanation is easily seen if we add to the water a few grains of a fine powder which will just sink and heat again from the bottom. The heated water will be seen to rise from the bottom carrying the grains of powder with it, the water in fact on being heated expands, becomes lighter than the cold water in the vessel and so rises, whilst the cold water at the top sinks and in turn becomes heated. When the heat is applied at the top no such result can follow, as the heated water, though lighter, is already at the top and hence the heat is not transferred. This process of heating a fluid or gas by movement of the lighter hot portions is termed *convection*, or carrying. Liquids in fact conduct heat very slightly, and it is by the movement of the particles that heat is distributed. Exactly the same process and explanations apply to gases, such as air.

We see then that there are two processes of transferring heat, viz., by conduction and by convection.

The first process will carry heat in any direction, the second only in a direction away from the earth's centre, that is, as we say, upwards, because bodies expand or become lighter on being heated.

But there remains another method of heat transference. When we sit by a fire we feel the heat. It comes across the air; it is not conducted, because the air is not a conductor; it is not convected because it comes horizontally, not vertically. We say IT IS *radiated*. A hot body transfers heat across a vacuum, across a gas, through solids, and liquids by a process due to a motion set up by the hot body in the universal medium we call the ether, which fills all space, whether occupied by material substances or not. Any number of bodies in a space radiate heat in every direction. The hotter a body the more it radiates, and hence between one body and another, the cooler one receives more than it radiates, the hotter one receives less than it radiates, till their temperatures are equal. Thus is heat transferred by ***radiation***. It involves no heating of the intervening space, if that be a vacuum, and very little if the intervening space be filled with air, heat in all cases and by all methods being transferred from a body at higher temperature to one at lower temperature, or, as we say for short, from hot to cold.

It will be desirable to consider rather more closely these three methods of heat transference, by conduction, by convection, and by radiation, as they all have applications in incubators.

The differences between them are fundamental, and must be clearly distinguished: confusion between them leads to much of the loose thinking about the action of incubators.

The hen transfers heat to the eggs almost entirely by *conduction*, by bringing her body into contact with the eggs to be heated. In the hot air incubator the heating is done by a process of *directed convection*, that is by heating air and then guiding it to the cooler eggs to give up its heat to them.

In the hot water or hot air *tank* incubator the heating is effected partly by *radiation*, that is, by putting a heated surface opposite to the eggs, the surface of which is then warmed by the heat radiated, and partly by convection, that is, by the eggs themselves warming the air which moves about and distributes the heat.

In all types of incubators the losses of heat take place by all three processes, that is, by radiation from the warm incubator to cooler objects in the room, by conduction through the walls of the incubator, and by convection by the discharge of warm air from the incubator in ventilation and otherwise.

TRANSFER OF HEAT BY CONDUCTION.

The importance of this question in incubators lies chiefly in its connexion with the loss of heat which occurs from the internal warm chamber to the external air. To get a clear conception of the processes involved, consider a piece of material in the form of a cube, say 1 inch cube, and that one face of this cube is maintained at a certain temperature by a source of heat, and the opposite face is maintained at a lower temperature.

Suppose, for instance, that these two faces are in contact respectively with vessels containing a considerable quantity of water at two different temperatures. Assume that the remaining sides of the cube are in some way covered so that no heat can escape from them. Heat now passes from the warmer face to the cooler one, flowing as we say, along the material of which it is composed. Measurements can be made of the rate at which the hotter vessel loses its heat and the cooler vessel gains heat by the transfer of heat thus going on, and by trying the experiment with a variety of materials we may draw up a table showing for each material the number of units of heat which will be conducted along it in unit time, when the difference of temperature between the opposite faces is one degree. Experiment has established that the flow of heat is proportional to the difference in temperature between the two faces, so that for any other number of degrees difference of temperature we only have to multiply the constant we have arrived at by the number of degrees difference of temperature which exist between the two faces.

The Table shows the number of British thermal units which will be conducted per second along a length of one inch with a temperature difference of one degree, the faces of the cube which are in contact with the warmer and cooler surfaces being 1 sq. in.

Table of Conducting Power of Materials.

Substance.	*British thermal units conducted per hour with 1°F difference of temperature.*	*Resistivities (see below)*
Copper	3.57	0.28
Iron	1.62	0.62
Stone	.116	8.60
Oak	.0118	85.
Walnut (across the fibres) ...	.0058	172.
Fir	.0052	193.
India rubber	.0095	105.0
Cork	.0080	125.0
Cotton wool	.0023	435.0
Blotting paper	.0019	520.0

For purposes of calculation it is convenient to adopt another point of view, that is, that the heat would pass instantaneously were it not that each material offers a certain resistance to the passage of heat, and to tabulate this resistance or *resistivity* as it is called for each material. It will be noted that the higher the conductivity the lower the resistivity. This is purely an arithmetical artifice; the physical action is related to the conducting power or conductivity.

The third column of the table sets out the resistivities of the substances enumerated above, the unit being the number of degrees Fahrenheit difference of temperature between the faces one inch apart which will be required to pass one unit of heat per hour across a surface of one square inch cross sectional area and one inch in thickness.

It will be noted that the materials in these tables are metals, wood, and, furthermore, various insulating packings, which are, as is well known, bodies which in themselves conduct very little, the interstices filled with air, the movement of which is restricted.

Speaking generally of the free space inside an incubator, the distribution of heat does not take place by conduction, but almost entirely by movements of air in convection currents, and it is only where the air is enclosed in the pores of some packing material that it acts in any appreciable extent as a conductor, and in this case the effect is so low that it may be treated as a non-conductor. compared with the material of which the packing is composed.

In the case of a space like the interior space of an incubator, the air inside has to warm the inner surface of the wall; the wall outside has to heat the surrounding air. Both these actions take place by movement of air over the surfaces, and involve a difference of temperature. The conditions are too complex to go into in detail, but within the limits of temperature occurring in an incubator the effect is of a *resistivity* at each surface expressible by the figure (approximated) of 245.

It is noticeable that the resistivity at the two surfaces is as great as that of two inches of cork, and as great as one inch of cotton wool.

If we take the ordinary case of an incubator having a wall 2¼ inches thick, composed of ½in. of wood on the inside, ½in. of wood on the outside and 1¼in. of packing material in between, having an average difference of temperature of 40°F (say 100° inside and 60°F outside) we should arrive at a flow of heat equal to 74 British thermal units per hour, and the mean external surface temperature of the incubator would be 6.5°F above that of the air, which corresponds well with experiment.

In this case approximately 7% of the insulation is due to the wood, 29% to the cotton wool, and 64% to the four surface transfers of the two layers of wood.

There is also a certain loss by radiation, which will be mentioned later.

TRANSFER OF HEAT BY CONVECTION.

The principles involved in the transfer of heat by convection are the following:

Air and all gases expand by heat 1/491 of their volume for every 1°F. change of temperature. Imagine a cu. ft. of dry air, say approximately that contained in a large biscuit tin, to be placed on one pan of a scale at a temperature of 60°F. This will weigh 536.3 grains. Suppose, on the other pan of the scale a similar container with 1 cu. ft. of air at 70°F. is placed—this weighs 526.2 grains. There is therefore a difference of approximately 10 grains. It is clear that the heavier container will sink and the lighter container will rise.

Bear in mind this is all taking place in the atmosphere, which we may suppose to be at the temperature of 60°F., the temperature of one of the containers. Now remove the balance and remove the containers, the same result will ensue, that is to say, that the heavier air will remain stationary, the surrounding air being of the same weight, whilst the lighter air will rise through and into the surrounding air, with which it will mix and part with its heat until it and the surrounding air are at the same temperature, when the movement will cease. If we have two tubes placed vertically containing air at these temperatures and a pipe connecting them at the bottom, each being open to the atmosphere at the top, the air in the tube which is heavier will sink down, drawing in air from the atmosphere, and press up the air in the tube which is lighter, displacing it into the atmosphere until in each tube the sum of the air weights is the same, when the movement will cease and each tube when the temperature has become steady will be full of air at the same temperature. In the same way, in any enclosed space, if there are differences of temperature between various layers, there will in general be movements set up, except in the one case where the hottest air is at the top and the coolest air at the bottom, in which case, there is no tendency to move, because the condition of stability where the heavier air is at the lowest point has already been reached.

In the enclosed spaces in an incubator the walls are usually cooler than the centre, because that is where the loss of heat takes place; consequently air inside the space tends to fall at the outside and to rise in the centre, the result being to circulate the air so that all points in turn are against the outside wall and all cooled. This result will be modified by the heating or ventilating air currents, that is, whether the air is entering from the bottom or air entering from the top for the purpose of heating or changing the air, and this point will be considered more fully when dealing with ventilation.

In tanks containing water the pipes conveying the heated gas from the combustible must be placed at the lower part of the tank, so that currents of convection may be set up, and the heat thus distributed throughout the water.

Transfer of Heat by Radiation.

If we fill a vessel with warm water and hang it in the air we shall find it gradually becomes cool. This, as might be expected, happens partly because the vessel heats the air in immediate contact, the movements already referred to set up and there is a constant supply of cool air to the outside of the vessel, the warmer air moving away and in this way the heat is removed. But we should find that even if we hung the vessel of hot water in a vacuum, where no such movement of air could result, it would still lose its heat ; the heat passes away even across the vacuum. We speak of this process as *radiation.* Measurements have been made of the rate at which different surfaces radiate heat, and it is found that this radiation depends entirely on two factors— one is the temperature of the surface and the other the nature of the surface from which the radiation takes place. The maximum radiation takes place from a black or unpolished surface. The minimum radiation takes place from white or highly polished surfaces. The radiation also depends upon the temperature of the surrounding objects to which it is radiating heat, because the actual mechanism by which radiation takes place and the temperature is affected, is that at all temperatures all bodies are sending out radiation, but they are also receiving radiation from surrounding objects, part of which is absorbed and part of which is reflected. The absorption and the radiation of a given surface are equal; if they were not, we should have substances which absorb more heat than they radiate, with the result that they would be continually getting hotter and hotter, a fact which, experience has shown, does not happen. The following table sets out the amounts of heat which would be radiated per hour from each square inch of the surface of a vessel filled with hot water when the surface from which the radiation takes place is that shown in the table, and when the surface is one degree Fahrenheit higher in temperature than the surrounding surfaces:—

Table of absolute radiating power of Surfaces.

Surface.	*Radiation B T U per hour per sq. in.*
Silver polished	.000185
Tin (bright)	.000304
Sheet Iron	.000640
Chalk	.004740
Sheet Iron (Rusty)	.004760
Wood	.005100
Paper	.005350
Lamp black	.005650

The practical importance of this question lies in this: if we desire to radiate heat from a hot vessel, such as the under side of an incubator tank, the side or part from which we wish radiation to place should be either a dull dark coloured surface or be coated with a dead black paint or varnish: if we desire to conserve heat the surface should be a highly polished metallic surface, or covered with a white colour with glossy surface. These facts are made use of in the heat retaining vessels known as the Thermos Flasks, where there are two glazed surfaces, silvered and therefore representing a highly polished metal surface, with a vacuum between them so that the losses of heat are by radiation only and those by the reflected surfaces are reduced to a minimum.

It may be added that if we have one surface radiating on to another through dry air or any ordinary dry gas there is practically no heating of the intervening air due to the radiation, and although moist air absorbs a certain amount of radiation, the amount so absorbed in the case of small enclosed space like an incubator is so small as to be negligible, and the heating of the air inside a space heated by radiation depends, as has already been stated, on the heating of some object in the space (such as a layer of eggs) by the radiation and the subsequent heating of the air by such surface in such a way that convective air currents are set up.

It is to be observed that the actual amount radiated is not large. In a tank machine the tank will be, say at 140°F, the egg surface at say 104°F, or 36° difference. If the tank has a dull black surface the total radiation from the tank per hour being, say, in 100 egg incubator, about 22 inches square, will be

22 x 22 x .00565 x 36 = 98 B T U per hour, or about 1 B T U per egg per hour.

The question always arises in connexion with the production and utilisation of heat, how much is produced, how much is utilised. In the case of a hot air incubator 100-egg size, a ⅞in. burner with flame ½in. high burned 1 oz. of oil per hour. An estimate of the various ways in which this heat is disposed of are given below.

The disposal of the heat produced by the lamp—Hot Air Incubator.

Total heat produced (B T U per hour)	1,200
Loss in waste gases from the chimney discharged at 310°F	500
Loss of hot air at open damper	300
Loss from exterior of heater	100
Loss from walls, etc., by radiation and convection	300
Loss in air discharged from machine	Very small.

It will be observed that a large margin for improvement exists, seeing that ¾ of the heat is lost before any of it enters the incubator, and the only heat needed by the eggs is about 100 B T U per hour, included in the 300 loss from walls, etc., above stated.

THE MEANING OF THE READINGS OF A THERMOMETER.

The foregoing explanations shew that heat may be transferred in three ways, and this has a bearing on the meaning to be attached to the reading of a thermometer. In a hot air insulator the reading shews the temperature of the air in which the bulb is placed. In a tank incubator it shews a temperature which is higher than that of the air as may be seen by placing a screen between it and the tank. In other words, in this case the upper surface of the eggs will be warmer than the surrounding air.

VENTILATION OR MASS MOVEMENT OF GASES.

The movement of air or gases under the influence of heat setting up convective currents such as have been described forms a general subject of the science of ventilation, the principles of which are comparatively simple. To clarify our ideas consider two vertical tubes or chimneys filled with air at two different temperatures; we have already seen that the air in these tubes is of different weight, the air in one tube for every degree Fah. of difference is lighter by 1/490—1/460th part than that in the other tube. So far as the relative pressure of the base of each column, this does not depend on the sectional area of the column, but only on its height, and we may imagine a column of unit size, that is, say, of one sq. in. in section. In any pair of such heated columns at different temperatures, there will, at the base of columns, be a difference in pressure, and we may, if we like, express this difference of temperature by stating the number of feet in height of a column of air at the mean temperature, which would give the same pressure as the actual difference of pressure existing. For example, if there are two columns differing in temperature by 1° and each of the columns is 460 ft. high, the difference of pressure at the bottom is equal to the pressure which would be created at the bottom of a single column one ft. in height. In other words, we express the difference of pressure as height or head in feet of the gas under consideration, and to measure the flow which would occur due to that head we have to consider what is the effect of that head in producing a velocity on air coming out from a hole under that pressure. It is shown in books on the subject that the velocity at which the air or gas will flow out of a hole under a pressure of 1ft. head is 8ft. per second, and this velocity is proportional, not to the head, but to the sq. root of the head, so we are able, in all cases, to calculate the velocity with which air will move through any opening if we know the head which is moving it, and knowing this velocity and the cross sectional area of the hole, we are able to tell the number of cubic inches which will flow per second. Certain allowances have to be made where the holes are small, or where the passage of air takes place through a pipe of some length to allow for the friction at the edges of the hole or on the surface of the pipe, but these allowances are not usually very large, and to a first order of correctness the process above described holds good.

In the case of the tank incubator the case is simple. The inside of the egg chamber is ventilated by an opening at the bottom and by holes generally slightly above the egg level. The average temperature in this space is about 85°F, and the outside air 60°F. The distance vertically between inlet and outlet is about 9in. In such case the velocity with which the air will move from the outlet if the inlet is freely open is 1.56 feet per second. This velocity multiplied by the area of the openings gives the total discharge. In the case of small round holes, such as are used in an incubator, the discharge is about .65 times that due to the full opening. As an example a standard incubator for 100 eggs has 8 discharge holes ½in. diameter. The discharge will be 8 x .128 (reduced area) x 18.7 (velocity in inches) = 19.4 cub. inches per second or 1,160 cu. in. per minute. If the inlet is constricted, if for example it had an equivalent area equal to the sum of the outlets, half the available head or motive force would be exerted at the inlet and half at the outlet, and as the velocity is as the square root of the head, the effect would be to diminish the flow in the ratio of 1 : $\sqrt{2}$, and the flow in the case given would be calculated as 815 cub. inches per minute. If the air has to pass over or through cloths as used on air moisteners, the velocity will be again diminished. In a case measured by me it was .7 of the above figure.

In the case of an incubator of the hot air type, the conditions are not quite so simple. In this case there are two columns of air to consider, and they may be imagined to be side by side. There is a column of hot air inside the heater chimney which is at a temperature of, say, 60° Fah. at the bottom and 167°F. at the top, a mean of 113½°. There is a column of air inside the incubator which is at 130° in the top chamber and 85° at the bottom, an average of 107½°. As long as the damper on the top of the heater chimney is closed, and bearing in mind that the final flow is downwards in the incubator, we have the following to consider :—

The air pressure at the base of the heater chimney and of the outlet of the incubator are the same, and they are at the same level. The air in the incubator is cooler than the air in the heater chimney by about 6°F , and the two columns which have to be considered are these two columns, and from this we might arrive at the head actuating the flow, and might consider the effect of this head upon the flow from the openings at the bottom of the incubator. But this is not the condition of affairs if the heater damper is open at the top. Suppose it is fully open, we now have to consider the column of air outside the heater and the column inside the heater, the difference in weight between these two columns will set up a downward flow outside the heater and upward flow inside it. In the same way, as far as the incubator itself is concerned, the downward pressure outside the bottom openings will be greater than the downward pressure on the inside in the incubator, and the air will, therefore, pass into the incubator at the bottom, and reversing the normal direction will flow up through the incubator, and join the air coming out of the opening under the damper from the heater chimney itself. So far as the air inside the incubator is concerned, therefore, the direction in which it moves will be downwards if the damper is closed, upwards if the damper is wide open, and it may be anything between these two. This, in fact, is the method by which the movement of the damper regulates the flow of air, and, therefore, of heat.

We consequently see that the ventilation in such a type of incubator does not depend alone on the size of the openings, or on the difference of temperature between the heater chimney and the incubator, but it also depends on the position of the damper. The position of this damper is of course regulated by the expansion capsule or thermostat, and will always be such that the supply of hot air to the incubator will carry in an amount of heat necessary to make good the loss which is occurring through the walls of the incubator. The amount of heat carried in will be proportional to the temperature of the incoming air. It follows, therefore, that the action of the thermostat and the position of the damper will depend on the actual temperature of the air in the heater, so that in this type of incubator the amount of air passing does not depend on the size of the openings or ventilation outlets or the extent to which they are open, *but depends only on the rate at which heat is lost from the walls of the incubator and on the temperature in the heater chimney.* In other words, the flow of air depends on the height of the lamp flame, and the degree to which the ventilating openings are regulated makes no difference to the flow of air, because the chimney damper always takes charge of this question in the manner which has been described above.

DIFFUSION OF AND MOLECULAR MOVEMENT OF GAS AND LIQUIDS.

If we have two vessels containing different gases, for example, air and carbonic acid, and connect these two vessels together by a tube or opening, then, whether we place the heavier gas at the top or the bottom, we shall find in course of time that the gases have mixed and that the average composition in each of the vessels is the same. If we consider two large vessels connected together by a fairly long tube we may examine a little more closely what happens. We will exclude the question of air currents set up by difference of temperature, and merely trace what happens in the interchange of the particles of gas in the one vessel with the particles of gas in the other. At the first instant one of the gases, say carbonic acid, is at the strength of full purity in one vessel, and at a strength of nothing in the other vessel. We shall shortly find if we are taking samples of the gas along the tube, that at every intermediate point along the tube the quantity of carbonic acid gas in a unit of volume would be in proportion between the full strength and nothing, simply depending on the distance we move along the tube, and the same would hold good of the air which is in the opposite vessel. In general, therefore, when two gases come into contact they move into one another and commingle by this process of diffusion, in which there is no general movement of the gases as a whole, but in which the individual molecules move relatively into one another.

The ratio at which different gases diffuse into one another has been measured. The rate depends on what is called the concentration gradient, that is to say, in the case of the tube I have illustrated, the difference in the quantity of the gas in each cubic inch of air at one end of the tube and the other divided by the length of the tube.

At a given temperature and pressure then the rate of diffusion depends on the change of strength per unit length, and the quantity diffused depends on this rate, and on the area of the tube along which the diffusion is taking place.

The table here following shows the weight in grains per hour that will diffuse along a tube one inch in sectional area, when the change of concentration per inch is one grain per cubic inch, the pressure being atmosphere. I only give the gases that concern us in an incubator.

Rates of diffusion into air.

	Grains per hour.
Carbonic acid diffusing into air	78
Water vapour ,, ,, ...	137

It is usual in incubator work to consider water vapour in terms of grains per cubic foot and carbonic acid in terms of parts by volume in 10,000 of air.

If we do this then

	Grains diffusing per hour.
Carbonic acid (gradient being one part in 10,000 per inch) into air	.0035
Water Vapour (gradient one grain per cu. ft. per inch) into air	.0782

By the process of diffusion it is possible for instance to remove the water vapour and the carbonic acid from the eggs in an incubator without any general passage of air through the eggs in the way expressed by ventilation, but there is a difference. If we have a space full of air and containing, for example, 5 grains of water vapour and 5 grains of carbonic acid in a cu. ft., then if by ventilation we pass a cu. ft. of air into the space, and a cu. ft. out of the space, we shall have removed 5 grains of each of these gases. If we put a space containing these quantities of water vapour and carbonic acid in contact with the surrounding air, which we will assume contains no water vapour or carbonic acid, we shall find the carbonic acid and the water vapour pass out into the surrounding air in unequal quantities, that is when the water vapour has become zero there will still be 2 grains of carbonic acid per cubic foot, and for them to pass out at the same rate into dry air the concentration of carbonic acid expressed in weight must be 1.67 times as great as the concentration of the water vapour.

EVAPORATION AND VAPOUR PRESSURES.

Substances are broadly divided into solids, liquids and gases, and as between these the matter is very largely one of temperature. All substances become gaseous if hot enough. Most substances become liquid at an intermediate stage, and many substances, even at temperatures round about ordinary temperatures, are on the border line of passing from liquid to gaseous. The so-called permanent gases, such as air, composed of oxygen and nitrogen, are liquid at atmospheric pressures if the temperature is sufficiently low.

Oxygen is liquid at--301°F, nitrogen at—316°F.

Carbonic acid gas is more easily liquified, and a temperature of 126°F. renders this gas liquid. A liquid such as water is entirely turned into a gas at ordinary atmospheric pressure at a temperature of 212°F, but even at lower temperatures a liquid such as water gives off some gas which we speak of as vapour ; in others words, it evaporates, and if contained in a closed space, will always give off a definite amount of vapour until for each temperature there is a definite amount of vapour in each cu. ft. of the space with which the liquid is in contact, which amount is constant for that temperature. This quantity is the maximum amount which that space will hold, and is said to saturate it.

It is important to realise that the *amount* of water evaporated in a given space does not depend on whether any air in other gases is present, or what those gases may be (always provided there is no chemical action with such other gases), but the presence of other gases makes a difference to the *rate* at which the space will be filled with water vapour. For example, if water is exposed in a vacuum at any particular temperature, the space will be filled almost instantly with the amount of water which such a space can contain at that temperature. If the space contains air at the same temperature it will finally contain the same amount of water vapour, but the rate of evaporation will be less. The actual rate at which the evaporation takes place to fill the space will furthermore depend upon whether the air is absolutely still or whether there are movements of the air, for reasons which will be apparent on noting the phenomena dealt with under the heading of " Diffusion."

The rate at which water evaporates in the presence of other gases depends on the difference between the amount of vapour which is already present in the space, and the amount which would be present if the space were saturated ; it also depends upon the actual temperature of the water, but for small differences such as occur in incubators, that is round about 100°F, the rate of evaporation may be taken as represented by the formula.

$$G = 5.85\ V\ (1 - p)$$

G being grains of water evaporated per hour from 1 sq. in. of surface of water ;

V being the vapour pressure (inches of mercury column) of the water vapour at the temperature ;

p the relative humidity or ratio of the vapour present to the vapour at saturation.

At 100°F. this formula gives the result shown here.

Table—Evaporation from surface of water in still air.

Temp.	Percentage humidity.	Grains of water evaporated per sq. in. per hour.
100°F.	100%	0
,,	80%	2.32
,,	60%	4.64
,,	40%	6.95
,,	20%	9.28
,,	0%	11.6

In view of the great effect on the rate of evaporation at any temperature of the percentage humidity at that temperature it is important to connect the percentage humidity at that temperature with the percentage humidity at any other temperature.

The table following shows the number of grains of water vapour required to saturate a cubic foot of space at different temperatures, and the ratio which this bears to the amount required at 100°F.

Table shewing grains of water required to saturate a cubic foot of space at different temperatures.

Temp. °F.	Grains per cu. ft.	Ratio at each temp. to that at 100°F.
100	.19.8	1
90	14.8	.75
80	11.0	.56
70	8.0	.41
60	5.8	.39
50	4.1	.21
40	2.9	.15
30	2.0	.10

That is to say, if we take air at any percentage humidity at one of the tempera tures on the first column and multiply by the figure in the last column, we obtain the percentage humidity at 100°F.

For example, at Greenwich the mean percentage humidity in January is 89%, in June 74%. But the mean temperature in January is 36°F, and in June 58°F.

So on raising the outside air to 100°F in an incubator, we arrive at the result that the percentage humidity in the incubator in January is 11.2% and in June 28%, and the evaporation in January 1¼ times as much as in June, quite contrary to the usual belief based upon the fact that at its own temperature June is a drier month than January.

Moreover, if the air in the incubator were desired to be passed in at 50% humidity at 100°F in January, it would be necessary to add 7.8 grains per cu. ft. of air passed into the incubator, and in June 5.9 grains per cu. ft.

If we know the quantity of air to be passed through the incubator and the temperature of the point where we place the water vessel, we can estimate the number of square inches of surface required to give the additional moisture.

If the incoming air is 400 cub. in. per min. or 14 cub. ft. per hour, to be brought from 20% humidity to 50% humidity at 100°F, the quantity to be evaporated is 9.9—3.9 = 6 grains per cub. foot, a total of 84 grains per hour. The mean humidity at which this is to be evaporated will be 35%, at which about 6½ grains per square inch will evaporate, so the surface to be exposed, if the air is freely moving over it, will be 13 square inches. If the vessels are put against the side walls of the incubator, the temperature will probably only be 90° and the area will have to be increased to about 18 square inches.

[*The concluding portion of the paper and the discussion will be printed in the next number of the* JOURNAL.]

OBITUARY.

GEORGE WATT CHRISTISON.—Mr. G. W. Christison, formerly of Darjeeling, died on November 19th in his eighty-eighth year. He was an old and respected Fellow of the Royal Society of Arts, having been elected some thirty years ago. At one time he constantly attended the meetings of the Indian Section and in 1896 he read a paper on "Tea Planting in Darjeeling," the chair being occupied by the late Sir Richard Temple, two other ex-Lieutenant-Governors of Bengal, Sir Steuart Colvin Bayley and Sir Charles A. Elliott, also taking part in the discussion. For his interesting and most instructive contribution—Sir Richard Temple described it "as about as good a paper as could possibly be given on this important subject"—he was awarded the Society's silver medal.

Though he was a pioneer in tea planting, his methods have contributed in no small measure to the continued prosperity of the Darjeeling tea gardens. One far-reaching boon he rendered to the whole tea industry was the introduction in 1878 of sulphur as a cure for red spider, one of the chief pests of the tea bush. The evil effects of deforestation in the Darjeeling hills caused him deep concern, and no man did more to stir up the Government in the matter, but the admitted evil still remains to a large extent without sufficient remedy.

After leaving India he settled in London, where his knowledge and experience were much sought after as a Director of Tea Companies

NOTES ON BOOKS.

HISTORIC WALL-PAPERS.—By Nancy McClelland. London: J. B. Lippincott Company. £5 10s.

In this very handsome volume Miss McClelland traces the history of the wall-paper industry from its beginning, about 1500, to the introduction of machine-printing, about 1840. The real development of the wall-paper idea is largely due to a group of men in France, known as the Dominotiers. The industry from which these craftsmen took their name was the making of "domino papers," which consisted for the most part of marbleised papers and of others with little figures and grotesques, crudely printed from wood-blocks and coloured by hand. Rouen was one of the chief centres of this industry, which was also carried on in some other French provincial towns. The papers were bought by the peasants to decorate their fireplaces, and they were also used as endpapers for binding books. Some of the designs were extremely tasteful and satisfactory. Miss McClelland gives an interesting account of the processes of this manufacture, and some attractive reproductions of early specimens of domino papers—notably one printed in 1700 by Dufourcroy of Paris.

Another illustration of great interest represents what is possibly the earliest known example of paper with a stamped design employed for decorative purpose in England. This was discovered in 1911 during the process of restoring the Master's Lodge of Christ's College, Cambridge. It was found covering a beam, and has been almost definitely proved to have been made by Hugo Goes, who was printing in York in 1509.

The first patent for making wall-papers in England was dated 1692. For many years the industry in this country suffered from heavy taxation and restrictions which were imposed by the Governments of the day. French manufacturers were not so handicapped, and they were able to use "endless paper" while English manufacturers were still compelled to work with short pieces. Between 1779 and 1824 the importation of paper-hangings into this country was entirely prohibited. The result was a striking lesson in political economy. As soon as the restriction was repealed production in England was greatly stimulated —so much so that the duty paid by paper-stainers rose from £34,246 in 1820 to £63,795 in 1834.

It is not possible with the space at our disposal to follow the author through the various periods into which she has divided the history of wall-papers. Suffice it to say she has spared no pains in collecting her materials nor taste in selecting her examples for illustrations. Of these there are twelve colour-plates and over two hundred half-tones. Amongst these it is interesting to note what a large number are specimens that had found their way over to houses in America as far back as the early eighteenth century.

All who are interested in the history of wall-papers will be grateful to Miss McClelland for her biographical conspectus of wall-paper designers, manufacturers and dealers, which contains over two hundred and eighty names. There is also a useful bibliography.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock, unless otherwise announced :—

DECEMBER 3.—PROFESSOR C. A. CARUS-WILSON, M.A., F.R.A.S., "The Teaching of Science in Secondary Schools." SIR ROBERT ABBOTT HADFIELD, Bt., D.Sc., F.R.S., will preside.

DECEMBER 10. (5.0 p.m.).—NORMAN THOMSON, "Colombia as a Field for Development." THOMAS J. IVE, Vice-President of the Anglo-Colombian Chamber of Commerce, will preside.

THURSDAY, DECEMBER 11.—Senatore Guglielmo Marconi, G.C.V.O., LL.D., D.Sc., Chairman's Inaugural Address, "Radio Communications."

INDIAN SECTION.

Friday afternoon at 4.30 o'clock :—

DECEMBER 5.—LIEUT.-COLONEL R. McCARRISON, C.I.E., M.D., LL.D., D.Sc., F.R.C.P., Indian Medical Service, "Problems of Food, with Special Reference to India." PROFESSOR HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., will preside.

PAPERS TO BE READ AFTER CHRISTMAS.

SIR ERNEST RUTHERFORD, M.A., D.Sc., F.R.S., *Trueman Wood Lecture.*

SIR J. FORTESCUE FLANNERY, Bt., Past-President of the Institute of Marine Engineers, "The Diesel Engine in Navigation." LORD BEARSTED will preside.

SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., "The Power of Internal Combustion Engines for Motor Cars."

MAJOR-GENERAL SIR WILLIAM SEFTON BRANCKER, K.C.B., Director of Civil Aviation, Air Ministry, "Commercial Aviation."

HENRY G. DOWLING, "Wall-papers."

CLAUDE H. FRIESE-GREENE, "Colour Cinematography."

J. S. OWENS, M.D., A.M.I.C.E., F.G.S., Superintendent Advisory Committee on Atmospheric Pollution, Air Ministry, Meteorological Office, "Modern Atmospheric Conditions."

SIR SAMUEL INSTONE, "The Thames Passenger Services."

CEDRIC CHIVERS, "Bookbinding."

PROFESSOR W. E. S. TURNER, O.B.E., D.Sc., F.Inst.P., Department of Glass Technology, University of Sheffield, "The Modern Production of Sheet-glass."

C. R. PEERS, C.B.E., F.S.A., Chief Inspector of Ancient Monuments and Historic Buildings. Subject to be announced later.

LIEUT.-COLONEL ANDREW BALFOUR, C.B., C.M.G., M.D. (Edin.), B.Sc., D.P.H., F.R.C.P.E., "The Trend of Modern Hygiene."

MRS. GRAYDON-STANNUS, "Irish Glass, Old and New."

CHARLES A. BAKER, Engineering Department, London County Council, "The Electrical Equipment of the London County Hall."

EMILE CAMMAERTS, "The Restoration of Public Buildings in Belgium."

LIEUT.-COLONEL SIR DAVID PRAIN, I.M.S., C.M.G., C.I.E., M.A., LL.D., F.R.S.E., F.R.S., *Sir George Birdwood Memorial Lecture*, "Government Botanical Gardens."

J. T. MARTEN, M.A., I.C.S., "The Indian Census."

SIR HENRY SHARP, C.S.I., C.I.E., M.A., "The Development of Indian Universities."

SIR GILBERT T. WALKER, C.S.I., M.A., F.R.A.S., Sc.D., Ph.D., F.R.S., "Indian Meteorology."

BRIGADIER-GENERAL SIR PERCY M. SYKES, K.C.I.E., C.B., C.M.G., "The Heart of Asia and the Roof of the World."

SIR ALFRED CHATTERTON, C.I.E., Assoc.M.Inst.C.E. Subject to be announced later.

LORD STEVENSON, G.C.M.G., "The British Empire Exhibition, 1924."

HON. WILLIAM G. A. ORMSBY-GORE, M.P. Subject to be announced later.

LORD BLYTH, "Penny Postage and Postal Communications Generally."

CANTOR LECTURES.

Monday evenings, at 8 o'clock.

LOUIS C. MARTIN, D.I.C., A.R.C.S., D.Sc., Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and Technology, South Kensington, "Modern Colour Problems." Three Lectures. November 24, December 1 and 8.

LECTURE II.—The psycho-physical basis of colour measurement. Specification of colour in terms of three variables. Colour systems and charts. Definite problems in colour measurement and their importance in Commerce.

LECTURE III.—Colours of material objects. Some colorimeters and their possible accuracy. Limited range colorimeters and nephelometers. General lines of progress. Probable limitations of these methods.

V. E. PULLEN, Director, Radiological Research Department, Woolwich, "Radiological Research—A History." Three Lectures. January 19, 26, February 2.

LECTURE I.—Natural Philosophy. The Fascination of speculative philosophy. The border line between science and philosophy. Early natural philosophy. Development of theory. Discovery of X-rays. Controversy as to their nature. Modern theory concerning X-rays. Relation to modern atomic theory.

LECTURE II.—Early apparatus. Early X-ray generators. Early vacuum tubes. X-ray tubes. Development of electrical generators. Development of X-ray tubes. The X-ray spectrometer. Measuring apparatus. Lines of modern radiological research.

LECTURE III.—Early applications of X-rays. Development of medical uses. Modern applications. Physiological dangers. Necessity for protection.

WALTER ROSENHAIN, B.A., B.C.E., D.Sc., F.R.S., Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory, "The Inner Structure of Alloys." Three Lectures. February 16, 23, March 2.

HOWARD LECTURES.

PROFESSOR JOHN SAMUEL STRAFFORD BRAME, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, "Motor Fuels." Three Lectures. April 20, 27, May 4.

DR. MANN JUVENILE LECTURES.

Wednesday afternoons, at 3 o'clock.

LIEUT.-COLONEL E. H. RICHARDSON. Two Lectures.

LECTURE I.—January 7.—"Dogs in War."
LECTURE II.—January 14.—"Dogs in Peace."

(Special tickets are required for the Dr. Mann Juvenile Lectures.)

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, DECEMBER 1..Geographical Society, Central Hall, Westminster, S.W., 8.30 p.m. Exhibition and description of M. Albert Kahn's collection of Photographs in Natural Colours.

Chemical Industry, Society of, at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m. Joint meeting with the Oil and Colour Chemists Association. Discussion on "Protective Paint Coatings."

University of London, University College, Gower Street, W.C., 5.30 p.m. Prof. W. S. Holdsworth, "The Influence of the Legal Profession on the Growth of the English Constitution."

At King's College, Strand, W.C., 5.30 p.m. Dr. R. W. Seton-Watson, "Austria-Hungary, 1867-1918." (Lecture IX).

At the Royal Academy of Music, Marylebone Road, N.W., 10 a.m. Dr. Leonard E. Hill, "Sunshine, Open Air and Health." (Lecture I).

Health, People's League of, at the Medical Society, 11, Chandos Street, W., 6 p.m. Dr. W. A. Potts, "Crime and Delinquency."

Engineers, Society of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m. Mr. H. A Rickwood, "Recent Developments in Ferro-Concrete Cooling Towers."

TUESDAY, DECEMBER 2..Petroleum Technologists, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m.

1. Messrs. A. W. Nash and H. G. Shatwell, "Fuel Oil Reserves of the Future."
2. Messrs. H. G. Shatwell, A. W. Nash and J. I. Graham, "The Somerset Oil Shales."

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m.

Metals, Institute of (Birmingham Local Section), Chamber of Commerce, New Street, Birmingham, 7 p.m. Mr. W. E. Ballard, "Metal Spraying."

(North-East Coast Local Section). Armstrong College, Newcastle-on-Tyne, 7.30 p.m. Mr. C. B. Brook, "Aluminium, its Production and uses."

University of London, King's College, Strand, W.C. Sir Bernard Pares, "Contemporary Russia from 1861." (Lecture IX).

5.30 p.m. Miss Hilda D. Oakeley, "The Philosophy of the Absolute in English Thought."(Lecture III.)
At the Royal Academy of Music, Marylebone Road, N.W., 10 a.m. Dr. Leonard E. Hill, "Sunshine, Open Air and Health." (Lecture II).

WEDNESDAY, DECEMBER 3..Public Analysts, Society of, at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m.
1. Mr. G. Van B. Gilmour, "The Analytical Value of the Melting Point of the Insoluble Volatile Acids from Fats."
2. Mr. A. H. Ware, "The Use of Mitchell's Ferrous Tartrate Reagent in Qualitative Analysis."
3. Mr. S. Glasstone, "The Influence of Hydrogen Ion Concentration on the Colorimetric Estimation of Pyrogallol and Catechol Derivatives."
4. Mr. B. S. Evans, "The Futility of Sealing: A Suggestion for its Safeguarding."
Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.
United Service Institution, Whitehall, S.W., 3 p.m. Major-General Sir George MacMunn, "The Quartermaster-General's Department and the Administrative Services in India from the Mutiny to the Present Time."
Sanitary Engineers, Institution of, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. H. A. Roechling, "House Drainage, with special reference to the Intercepting Trap."
Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. (Wireless Section), Mr. G. Shearing, "Wireless Telegraph Valve Transmitters employing Rectified Alternating Currents."
(South Midland Section), at the University, Edmund Street, Birmingham, 7 p.m. Mr. G. Rogers, "Automatic and Semi-Automatic Mercury-Vapour Rectifier Substations."
Chadwick Public Lecture, at the Medical Society, 11, Chandos Street, W., 5.15 p.m. Dr. W. M. Feldman, "Post Natal Child Physiology and Hygiene."
University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. I. Björhagen, "Sweden, its Land and People."
At the School of Oriental Studies, Finsbury Square, E.C., 5 p.m. Mr. S. Topalian, "Armenia in the Fourth Century."
At the Royal Academy of Music, Marylebone Road, N.W., 10 a.m. Mr. F. Roscoe, "The Musician as Teacher."
8 p.m. Sir Johnston Forbes-Robertson, "An Actor's View of Shakespeare."
Public Health, Royal Institute of, 37, Russell Square, W.C., 4 p.m. Dr. C. K. Millard, "The Disposal of the Dead."

THURSDAY, DECEMBER 4..Engineering Inspection, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m. Mr. J. E. Sears, "Accurate Gauge Work."
Metals, Institute of (Sheffield Local Section), at the University, St. George's Square, Sheffield, 7.30 p.m. Joint meeting with the Silver Trades Society. Discussion on "Electro-Plating."
Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. Prof. J. G. Gray and Mr. J. Gray, "Gyroscopic Pendulums."
British Acetylene and Welding Association, Old Colony Club, Aldwych House, Aldwych, W.C., 8 p.m. Mr. H. J. Gough. "Fatigue of Metals."
Mechanical Engineers, Institution of (Glasgow Centre), Royal Technical College, Glasgow, 7.30 p.m. Report of the Marine Oil-Engine Trials Committee.
Linnean Society, Burlington House, Piccadilly, W., 5 p.m.
1. Dr. G. C. Druce, Exhibition of *Epipogum aphyllum* and other British plants.
2. Miss V. Nay, "The adult and juvenile forms of *Sophora tetraptera* vars. *microphylla* and *prostrata*."
3. Miss V. M. Grubb, "The development and liberation of spermatia in some previously undescribed cases."
4. Prof. E. G. Goodrich, "The Cranial Roofing Bones in Dipnoi Fishes."
Chemical Society, Burlington House, Piccadilly, W., 8 p.m.
Messrs. H. Burgess and T. M. Lowry (*a*) New halogen derivatives of camphor. Part VI. β-Bromo camphor-α-sulphonic acid.
(*b*) New halogen derivatives of camphor. Part VII. The constitution of the Reychler series of camphorsulphonic acids. Experiments on chlorosulphoxides.
Philological Society, University College, Gower Street, W.C., 5.30 p.m.
Child Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. Miss Octavia Lewin, "Some Physical Causes of Mental Deficiency."
Aeronautical Society, 7, Albemarle Street, W., 5.30 p.m. Colonel F. Searle, "The Maintenance of Commercial Aircraft."
Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.
Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.
London County Council, at the Geffrye Museum, Kingsland Road, E., 7.30 p.m. Mr. J. Starkie Gardner, "English Ironwork."
University of London, King's College, Strand, W.C., 5.15 p.m. Prof. J. W. Allen, "The Social and Political Ideas of Some Great Thinkers of the Renaissance and Reformation." (Lecture VII). Martin Luther.
5.30 p.m. Mr. M. Beza, "Pagan Remnants in Roumanian Folklore," (Lecture I).
5.30 p.m. Prince D. S. Mirsky, "The Russian Novel from Turgenev to Chekhov." (Lecture IX).
At the Bedford College for Women, Regent's Park, N.W., 5.15 p.m. Dr. J. F. Spencer, "The Historical Development of the Conception of the Atom."
At the Royal Academy of Music, Marylebone Road, N.W., 10 a.m. Prof. T. P. Nunn, "Psychology and Mental Growth." (Lecture I).

FRIDAY, DECEMBER 5..Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m..
1. Prof. F. C. Lea, "The Effect of Low and High Temperatures on Materials."
2. Mr. J. M. Lessells, "The Elastic Limit in Tension and its Influence on the Breakdown by Fatigue".
University of London, King's College, Strand, W.C., 5.30 p.m. Dr. E. S. Russell, "Scientific Method."
At the Royal Academy of Music, Marylebone Road, N.W., 10 a.m. Prof. T. P. Nunn, "Psychology and Mental Growth." (Lecture II).

SATURDAY, DECEMBER 6..University of London, at the Royal Academy of Music, Marylebone Road, N.W., 10 a.m. Lecture by the Principal.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

No. 3759 VOL. LXXIII.

FRIDAY, DECEMBER 5, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, DECEMBER 8th, at 8 p.m. (Cantor Lecture.) LOUIS C. MARTIN, A.R.C.S., D.Sc., Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and Technology, South Kensington, " Modern Colour Problems." (Lecture III.)

WEDNESDAY, DECEMBER 10th, at 5 p.m. (Ordinary Meeting.) NORMAN THOMSON, " Colombia as a Field for Development." MR. THOMAS J. IVE, Vice-President Anglo-Colombian Chamber of Commerce, will preside. Tea and Coffee will be served in the Library at 4.30 p.m.

THURSDAY, DECEMBER 11th, at 8 p.m. (Ordinary Meeting.) SENATORE GUGLIELMO MARCONI, G.C.V.O., LL.D., D.Sc., Chairman's Inaugural Address, " Radio Communications." Tea and coffee will be served in the Library after the meeting.

THIRD ORDINARY MEETING.

WEDNESDAY, NOVEMBER 26th, 1924. MR. ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council, in the Chair :—

The following candidates were proposed for election as Fellows of the Society :—

Caffoor, N. D. H. Abdul, Colombo, Ceylon.
Hodgson, Edgar Stanley, Whitefield, Lancs.
Hopkins, Miss M. H., London.
Kielberg, Ferdinand K., Liverpool.
Sporborg, H. N., Rugby.
Wolton, John David, Mem.Am.Soc.M.E., London.

The candidates proposed on November 12th, a list of whom was published in the *Journal* of November 21st (pages 3-4) were duly elected Fellows of the Society.

A paper on " Talking Motion Pictures " (with practical demonstrations) was read by Mr. C. F. Elwell, B.A.

The paper and discussion will be published in the *Journal* of December 12th.

CANTOR LECTURE.

On Monday, November 24th, MR. NOEL HEATON in the Chair; DR. LOUIS C. MARTIN, A.R.C.S., D.Sc., Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and Technology, South Kensington, delivered the first lecture of his course on " Modern Colour Problems."

The lectures will be published in the *Journal* during the Christmas recess.

DR. MANN JUVENILE LECTURES.

Under the Dr. Mann Trust a short course of lectures adapted to a juvenile audience will be delivered on Wednesday afternoons, 7th and 14th January, 1925, at 3 p.m., by LIEUT.-COLONEL E. H. RICHARDSON, on "Dogs in War" and " Dogs in Peace." The lectures will be fully illustrated with lantern slides, and by the dogs themselves.

Special tickets are required for this set of lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to tickets admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

PROCEEDINGS OF THE SOCIETY.

SECOND ORDINARY MEETING.

WEDNESDAY, NOVEMBER 19TH, 1924.

MR. EDWARD BROWN, F.L.S., President of the International Association of Poultry Instructors and Investigators, in the Chair.

THE SCIENTIFIC PRINCIPLES OF ARTIFICIAL INCUBATION.

By LLEWELYN B. ATKINSON, M.I.E.E.,

Past-President of the Institution of Electrical Engineers.

(Concluded from page 55).

AUTOMATIC REGULATION.

The early incubators, like the incubation methods of the Chinese and Egyptians, depended on the operator's constant watchfulness and skill in maintaining the temperature and other conditions.

An important feature of incubators which are not to be continually watched and personally regulated is a method of insuring constant temperatures, and this is done by Automatic Heat Regulators or Thermostats.

These automatic regulators have to be arranged so that they will control the flow of the hot gases used for heating hot water or hot air, or control the supply of hot air to the incubator, or in the case of gas-heated incubators control the flow of gas to the burner, or in the case of electric incubators control the amount of electric current heating the wires.

The movements producing these controlling actions are given by effects produced by the expansion of solids, such as metals, or of liquids, such as mercury, or by the variation of vapour-pressure of fluids in an enclosed space, as in the case of Hearson's Capsule Regulator.

The method of obtaining the movement required by the expansion of metals is to utilise compound bars built up of two metals, so that when heated these expand at different rates and cause one or both of the metal bars to bend and give the movement required. Thus a bar of iron which at 55°F. is 10 inches long, at 100°F. will become 10.0030 inches in length, and a zinc bar will have become 10.0078 inches in length. If these two are so arranged and fixed that the iron bar remains straight whilst the zinc bar bends at the centre, the centre will move from the iron bar to a distance of .0048 inch. If we multiply this movement by 100 to 1, which can easily be done by levers, the damper will rise by .48 inch, in approximate figures ½ inch. Two such bars joined up so as to add their effect would give double the movement, or say 1 inch. This is equivalent to a movement of the damper of 1/50 inch, approximately for a change of temperature of 1°F. This is a small quantity, and a bar would need to be about twice this length to be effective. This type of regulator, however, in skilful hands gives very good results.

In the Capsule Regulator, which has already been referred to as taking so fundamental a part in the construction of the successful Hearson incubator, a thin metal container having its upper and lower surface corrugated, has placed in it a few drops of a fluid which evaporate, or in other words, give a considerable vapour-pressure at or about the temperature at which the incubator has to be regulated.

The capsule regulator is not well understood. The vapour pressures of certain fluids are shown by the curves on the diagram.

These are expressed in inches of mercury of the barometer column. For all pressures below 30 inches the pressure of the atmosphere will keep the upper and lower surfaces of the capsule in contact. At 30" mercury column pressure the capsule surfaces will separate, at first very easily and then more slowly, as the movement requires the bending of the curves of the corrugations, like a spring. It is necessary, therefore, to have a fluid which gives a pressure equal to 30in. or greater than mercury column at the selected pressure. For maximum sensitiveness the change in vapour pressure for one degree of change of tempera-

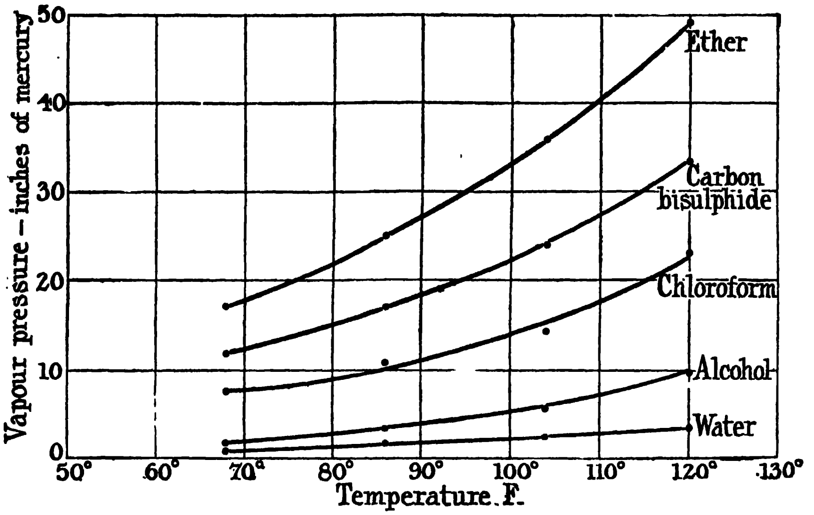

FIG. 1.—Fluid vapour pressures at various temperatures.

ture should be as great as possible, that is the curve should be steep, and finally the load on the capsule, including that of the atmosphere, should be such as to hold it at the point where the surfaces have only just separated at the specified temperature. In other words, taking the two adjustment elements in the arrangements ordinarily used, the position of the regulator should be such that the damper will just be on the point of lifting when the capsule is closed, and the temperature at which it moves then adjusted by loading. The weights on many capsules, placed as they are in the incubators, are insufficient for this, and consequently the capsule is worked partly open, and the resistance to stretching of the capsule surfaces relied upon to assist the weight, but under this condition the movement for a given change of pressure is less. To illustrate this, consider a frictionless piston in a cylinder, with a dead-weight load on it; the moment the pressure under the piston exceeded that of the atmosphere it would move the whole length of the cylinder. If there were a spring on the top, instead of a dead-weight, it would only move sufficiently to cause the spring to again balance the internal pressure.

The loading is partly the weight of the atmosphere and partly the weight on the lever. The atmospheric pressure varies with the barometer and a range of 1¼in. mercury is common. With an ether-filled capsule working at 103° this would correspond to a vapour pressure change equivalent to 2°F. With ether as the fluid at 103° a total loading equivalent to 35in. of mercury is required, and with capsules of 2.8 square inches area the added loading must be equivalent to about 5 lb. weight per square inch, or half this applied at the centre. This would be given a weight of 4½ oz. (a usual weight to use) with a lever ratio of 9 to 1. The lever ratio is often about 20 to 1 as a maximum. The capsules in many incubators are placed at a point where the temperature is as high as

110°, and this corresponds with ether to a pressure of 40in. mercury, and the added weight would be 5½lb. at the centre, and this would require the 4½in. weight at 19½ lever ratio. Owing to lack of radial stiffness capsule regulators will bulge without lifting the weight if it exceeds about 10lb.

A greater sensitiveness, if required, would be obtained by using a fluid with a considerably greater vapour pressure at 103°, which is accompanied by a sharper rise of vapour pressure, and to meet this by a greater loading in the capsule. Speaking generally, however, properly adjusted present capsules are quite sufficiently sensitive.

BIOLOGICAL FACTORS IN INCUBATION.

In all living organisms the starting point is the single cell, a discrete unit of nitrogenous substance, comprising already the potentiality under certain circumstances of growth, of self building by adaptation of materials from its environment, and finally acquiring the power of transmitting part of these powers to other cells of the like kind. The how and the wherefore is the riddle which science will presently reply to, but here it suffices to point out, that in the highest organism the fertilisation and the building up from the single cell is completed within the body of the parent, in the birds, fishes and reptiles, and insects, is partly so carried out, but completed externally to the parent, whilst in the lowest forms of life the process commencing with the fission or division of a cell from the parent body proceeds wholly without assistance from the parent.

The highest forms of life, the mammal, the reptile, fish, and insect, require ordinarily the co-operation of two classes of cells, respectively termed male and female, to effect "fertilisation," or to bring about those atomic or molecular disturbances of the cell material which causes the reactions of which life and growth are the effect, whilst in the lowest forms the fissioned or divided cell appears already to have these properties, and intermediate are a class of life form, whose partially developed structure or eggs may be endowed with the growth impetus either by sex fertilisation or by purely chemical stimulus.

So far as concerns us here, the bird requires the duality of sex, the male or cock the female or hen.

When in the case of the hen the single cell or germ cell is fertilised, processes of growth build this into the embryo, which already has developed the germ cells which within the life of the bird to be may become the eggs which she produces, determined in number, not to be added to, only to be developed; so that all that human arrangements can do is to lengthen or shorten the period during which these germ cells will be developed and matured into eggs.

The process of development of the fertilised egg has already begun before the egg is laid, and whilst this is not the place to study closely the whole history of the embryo within the egg, a general examination of the processes which go on in the 20 or 21 days in which an egg is under incubation may be indicated as follows :—

The first 5 days are occupied in the development of the various organs coupling the embryo with the yolk, and with the allantois forming the food supply and respiratory organs, with which to nourish the embryo and to aerate the blood until hatching time. During this time, as may be expected, the actual life process, considered as a process of oxidation of the food stuff of the yolk, is at low point, because in fact, the necessary organs are only being developed.

The second 5 days are occupied in the formation of all the elements of the skeleton or bony structure, and the various internal organs and the rudimentary feathers; and the living process, again as measured by oxidation, is in a more active state.

The third and fourth stages, say of 5 days each, run into one another, but the most remarkable change takes place between the 10th and 13th day, when the living process measured again by oxidation, increases at an enormous rate and is, by the 13th day, on an entirely different scale from what it was at the early part of the operation.

The production of carbonic acid by the embryo, indicating the activity of the living process, seems to be so important a measure of the actions going on that I have devoted much attention to this question, and have made measurements of the production at different stages of the incubation of the egg. Much more refined and detailed measurements have, however, been made by Mr. Horace Atwood at the West Virginia Experimental Station, U.S.A. More than a year ago he very kindly gave me his results, which have since been published.

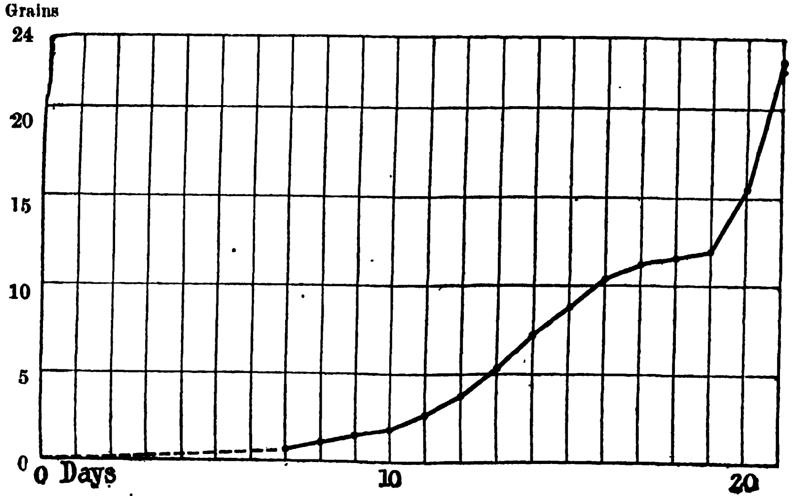

FIG. 2.—Grains of Carbonic Acid produced at each day of Incubation from Horace Atwood's experiments.

The curve shown here gives day by day the grains weight of carbonic acid produced by an egg of normal weight. It will be seen that the production increases very slowly up to the tenth day, and then rapidly increases till the 19th day, and at the 21st day is on a scale such that it is equal to that produced on the whole of the first fourteen days.

Whence does this carbonic acid come? It comes from the oxidation of the carbon of the contents of the egg, principally the yolk.

In the yolk albuminoids form 16% and fatty substance 31.4%.

The albuminoids contain approximately 53% carbon and 7% hydrogen.

The fats contain approximately 74% carbon and 12% hydrogen.

It appears reasonable to infer that the fat only is used to support the vital actions, the albumins being utilised for growth and to repair waste. On this assumption we may calculate that the carbon consumed is 27½% of the weight of carbonic acid produced, and that the hydrogen consumed is 11% of the weight of the carbonic acid, with an amount of internal oxygen which is negligible.

The following table shows at specific dates (1) The carbonic acid produced. (2) The carbon consumed. (3) The hydrogen consumed. (4) The total of carbon and hydrogen. (5) The oxygen to be supplied from outside to carry on the oxidation, being about one fifth of the air necessary. (6) The approximate total loss of weight in normal incubation. (7) The balance, which is *water* evaporated from the substance of the egg. All weights are grains in 24 hours.

TABLE.

Day of Incubation.	Carbonic acid produced (1)	Carbon consumed. (2)	Hydrogen consumed. (3)	Total consumed. (4)	Oxygen required (5)	Normal loss of weight. (6)	Water evaporated from substance of egg. (7)
2	.131	.036	.0057	.042	.142	3	2.95
5	.48	.131	.0205	.152	.513	3	2.85
10	1.94	.53	.083	.613	2.06	4 gr.	3.38
15	8.85	2.42	.376	2.80	9.5	4 gr.	2.20
20	15.5	4.23	.66	4.89	16.7	5.5	.61

How does the oxygen required reach the egg? How does the carbonic acid escape? How does the water come out? Writers treat this question as if the shell and membranes were porous.

The shell is porous, but the membrane, in the ordinary sense is not porous, as will be evident if we remember that eggs which decompose and generate sulphuretted hydrogen will burst with an explosion if dropped and broken.

The gases pass by a process known as atmolysis. It is a process which involves a chemical action of some kind so that the gas to be passed through enters into chemical combination at one side of the membrane, and passes out of combination at the other side.

Rodendorf has measured the quantity of air which will pass through the membrane of a hen's egg per hour as follows:—

Difference of Pressure on two sides of membrane in atmospheres (15 lb. per sq. inch).	*Quantity diffused in cubic centimetres per hour.*	*Quantity diffused in grains per hour.*
0.1	9.07	.18
.2	18.46	.37
.3	35.57	.71
.4	71.09	1.42
.5	147.15	2.94
.6	286.90	5.72
.7	566.20	11.32
.8	1127.	22.54
.9	2358.	47.16

On these figures to pass the air necessary to support the combustion on the 20th day, would require about .6 atmosphere difference of pressure. This, I think, does not exist. But it may be that after the first air has passed in, the oxygen being absorbed and the nitrogen left, this nitrogen, getting at a higher concentration than the outside nitrogen, diffuses out, and oxygen only diffuses inwards, in which case, four atmosphere difference of pressure would be necessary. I do not think this exists either; so we are forced to the conclusion that difference of concentration of oxygen alone is the motive force for causing the diffusion of oxygen into the interior space.

I have dwelt at considerable length on this carbonic acid problem because this is all-important; it is by means of carbonic acid that lime is taken from the shell and passed into the skeleton of the chick. It is important again in its bearing on the amount of ventilation necessary in incubators, and this has its connexion with the problem of evaporation.

The combustion of the yolk necessarily produces heat. We have seen that in the Egyptian hatcheries after the tenth day no fuel is used; in some large American hatcheries cool air has to be circulated to keep the temperature down. How much heat is produced? It may be calculated thus. The carbonic acid produced on the seventeenth day is 11.2 grains in 24 hours, produced by 3.1 grains of carbon, which corresponds with 5.7 grains of fat. 1 grain of fat produces 2.4 British thermal units, so the heat produced is 13.8 B.T.U. per day or .58 per hour.

In an experiment made on an egg at seventeenth day, when I determined the rate of cooling of a live egg, with the rate of cooling of an infertile egg from the same temperature, I arrived at a figure of 1.2 B.T.U. per hour as the amount of heat produced by the egg. The amount needed to supply the heat losses under the conditions of ordinary incubators may be estimated in several ways. I have found that the quantity of heat which must be given to an egg at the earlier stage of incubation, when its own production is practically nil, is the same as can be passed through a piece of rubber sheet .004 thick on an area of ½ a square inch with a difference of 1°F between the top and bottom of the sheet, which works out at 1.18 B.T.U. per hour. Earlier it was calculated that the amount of heat radiated from the tank was about 1.0 B.T.U. per egg; and further 30 watts electric energy is used in a 100 egg incubator, giving 1.03 B.T.U. per egg. These figures substantially agree.

The rate of loss of water by evaporations from an egg may be conditioned or limited by one of two factors. The evaporation may be that due to a moist surface in an unsaturated atmosphere, the moisture being replaceable at a rate greater than the evaporation, or it may be limited by the amount which reaches the surface, the rate of supply being less than the possible evaporation. To make a comparison, consider an egg having a surface of about 6 square inches. The evaporation from a wetted surface at 100°F. in an atmosphere say of 40% humidity would be, we have already seen, 6.95 grains per hour, or 41.7 for the surface of the egg. Clearly it is not a case of a freely supplied surface.

Experiment on an egg from which the contents had been blown out—the egg nearly filled with water and the hole sealed showed the following: At 100°F in 45% humidity the evaporation was 7 grains per 24 hours. The same egg for many months at average temperature of 60°F, and humidity 65%, evaporated 1.6 gr. daily. The two cases show a ratio of 4.3 : 1. If we calculate the evaporation from a free surface at these temperatures and humidities, we find the evaporation would be per square inch per hour respectively 6.15 and 1.08 grains, a ratio of 5.7 : 1, so the ratio is of the same order as on a free evaporation surface, the amount, however, being about that of a surface $\frac{1}{21}$ of the actual size. It is clear that the supply of water to the surface is the limiting factor.

MEASUREMENTS AND CALCULATIONS ON EXISTING TYPES OF INCUBATORS.

It is only of recent years that any measurements have been made on the important factors connected with incubators with the one exception of temperature, in connexion with which great care has been exercised; but it is now recognised that the amount of ventilation which decides the concentration of carbonic acid, and the humidity are all-important factors. While there has been immense discussion on these matters and a great deal of theorising, ordinary incubator workers are quite in the dark as to what is required, or of methods of measuring or regulating them.

For the last three or four years the author has been making measurements of these quantities and simplifying the method of measuring them, so that their control may become part of the normal operation of incubators.

MEASUREMENT OF AIR FLOW.

The first element the measurement of which was undertaken was the actual quantity of air passing through various types of incubators, which may be conveniently expressed as a number of cubic inches of air passing per egg per minute. It has to be borne in mind that the quantities are small, and that they cannot be measured by usual types of meters, because these require a moderate pressure of gas to work them, which is not available in this case.

The first method by which the writer attempted to make these measurements was by filling a long tube or glass vessel with smoke, connecting this to the outlet of the incubator and noting the time which it took for the smoke-laden air to be replaced by pure air. Consistent results were obtained by this method, but it was very slow and rather disagreeable to work. This was replaced by a simple instrument comprising a box with a closed top, inside of which was suspended a light mica vane. When air passed through the box from the inlet on one side to an outlet on another side this vane was deflected by an amount which was related to the speed of the current of air. The instrument was graduated by passing measured quantities of air per minute through the instrument, and once it was graduated and being applied to the outlet of the incubator, the quantity of air passing per minute could be observed by the movement of the needle of this simple instrument. The only question involved in applying this to different types of incubators was the putting of collectors of different forms to the different makes to ensure collecting the air passing from or through them without actually throttling or disturbing the flow. The table below shows in certain incubators of certain types the quantity of air passing per egg per minute when the incubator was carrying the rated quantity of eggs. The same apparatus was used to measure the air flowing through the nest of a hen, this nest being placed in a box totally enclosed above the level of the nest except for the outlet to the measuring instrument.

The wide variation in the air passing through these various types of incubators shows that it has no relation to the actual necessities of the case, in fact in the hot-air incubators it depends on the quantity of heat that has to be carried in, and not on the quantity of air required by the eggs.

Table showing the quantities of air per minute per egg passing through various types of Incubators.

Type.	*Cubic inches of air per minute per egg.*
(1) Hot water tank.	
Ventilator nearly shut	1.40
Ventilator full open	5.00
(2) Hot air type.	
Medium flame	
Ventilator open	5.5–9.3
Ventilator closed	ditto

	Ratio
Lamp turned high and damper open .133"	3
Lamp turned low, damper nearly down .033"	1
(3) Hot air tank radiating on eggs; no through ventilation.	Practically Nil.
(4) Hen's nest open bottom	7.0
(5) Hen's nest on ground	Estimated 1.2
(6) Quantity necessary at end of hatch to keep CO_2 to 100 parts in 10,000 ...	2.39

MEASUREMENT OF HUMIDITY.

The measurement of the moisture or humidity of the air in the incubator has been attempted in various ways. The method of using what is known as the dry and wet bulb thermometer, evaporation from the surface of the wetted bulb cooling one thermometer so that a different reading is obtained between the two, from which the percentage of humidity of the air can be determined, is an attractive method, but unfortunately it is known that the results are unreliable unless there is a movement of air of about 9 ft. per second, which does not exist in incubators.

Various methods involving the principle of measuring the temperature at which dew can be deposited were tried, and a very simple apparatus can be used along these lines without much trouble.

A highly polished metal vessel is fitted with a cork through which passes two tubes, one of which passes to the bottom of the vessel and the other goes out at the top. Two small rubber tubes are brought out through any convenient hole, and the thermometer is passed through the same cork into the interior of the same vessel. If this vessel is now placed in the egg chamber it, and the air inside it, will soon be at the temperature of the incubator. If air from outside the incubator be now drawn gradually in the vessel, either by sucking one of the tubes or by the use of a small rubber air ball, the air inside will be lowered in temperature, the metal vessel will be cooled, and a point will be reached when dew will be deposited on the vessel, and the temperature of this point being noted, the percentage humidity can be found by a table in a manner well-known.

Whilst this method is a suitable one for making measurements, it is not a convenient one for regulating the condition, or for making measurements in confined spaces, actually between the eggs, etc.

Another method which the writer has used is to actually measure the evaporation from the surface of blotting paper kept moistened, being supplied with water from a small graduated vessel on the top of which it rests. This method gives consistent results, but again is not applicable except on the incubator tray for measuring the humidity of the atmosphere of the incubator, not between the eggs.

A method of measuring the humidity which the writer has used, and which he finds has been used by Capt. Cadman, is based on the change of colour of paper which has been moistened with certain chemical salts ; suitable salts are those of cobalt, chloride, bromide or iodide, or mixtures of them, which form different hydrates at different vapour-pressures, these hydrates being of different colours. By placing small pieces of such paper in various parts of incubators or among the eggs, or in hens' nests, and comparing the colour arising with colours which have been standardised at known humidities of degree, the humidity may be ascertained with very considerable accuracy.

An instrument based on these principles, in which a piece of such chemically-treated paper is surrounded by a mask of the colour which the paper will assume at the correct humidity, has been devised by the writer, and is a perfectly simple and reliable method of enabling the correct humidity in an incubator to be measured, and so maintained under all conditions.

The use of this instrument and these methods has shown that practically every type of incubator has the air, particularly in the spring months, too dry. Humidity readings of 20% and 30% are usual, and in this connexion attention should be called to the great absorption of moisture by the wood and packing used for the walls of incubators. These materials will absorb at saturation point 25% of their weight of water, and will absorb moisture from eggs many times the weight of the water which needs to be disposed of. The application of water towards the end of a nitch is of doubtful utility, but at least it prepares the incubator for the next hatch, and herein its usefulness probably lies.

MEASUREMENT OF CARBONIC ACID.

The measurement of carbonic acid in air is usually performed by the process of drawing the known volume of the air through alkaline salts and observing the amount which is absorbed.

This method, though accurate, requires great care in performing it, and is quite beyond the scope of ordinary incubator workers.

A method which the author had devised and used with consistent results consists of applying to a small piece of blotting paper which has been treated with a colour-indicator a definite quantity of a standardised alkaline solution. The paper will then be of a definite colour. It is introduced through a small hole into the part of the incubator where it is required to know the percentage of carbonic acid, and the time is noted in which the paper undergoes the colour change due to the neutralisation of the alkali by the carbonic acid.

To obtain the definite quantity of alkali on the porous paper it is only necessary to apply the alkali to a small part or spot of the paper ; it then spreads by capillary attraction until the part that is wetted is wetted by a definite amount per unit of area.

It is easy to arrange with an instrument of this kind that at the highest concentration of carbonic acid likely to be found in an incubator, the colour change takes place in about three minutes, and that at the normal concentration the colour change takes place in about eight minutes.

The table below shows some results obtained of percentage humidities and concentration of carbonic acid in standard types of incubators worked in accordance with instructions of the makers, in an atmosphere with external humidity 65% at 60°.

TABLE.

Type, etc.	*Humidity %* *at* 103°	*Concentration of Carbonic Acid at end of hatch parts in* 10,000.
1. Hot water tank ... ... Ventilation full open, with moisture tray in ...	49%	50
2. Hot air tank practically no ventilation ... ... No moisture tray	45%	200
3. Hot air machine ... ... Moisture tray in	30%	36
4. Mammoth incubator	20%	average 100

Speaking generally, whilst these results exhibit considerable variation, they show that so far as these particular incubators are concerned there is no serious departure from the proper conditions. Generally all types of incubators suffer from too much air, and too low a concentration at the earlier stages, with the result that the air is too dry. This cannot be avoided in hot air machines; all that can be done is to add moisture and keep the humidity up to about 50%.

The result of making measurements by the simple means described, and of controlling moisture and carbonic acid to correspond with the conditions shown in a hen's nest, proved of great assistance in obtaining regular and consistent results with given types of incubators, but nevertheless, there still appears to be an advantage possessed by the hen over the incubator arising from some factor in operation in the incubator.

INCUBATION UNDER THE HEN.

It seems a reasonable proposition that if we imitate the natural process of incubation the best results will be obtained, and to do this the conditions should be studied. They have been studied by a good many experimenters of recent years, and there are separate studies of temperature, humidity, carbonic acid, spread through many bulletins, reports and papers existing. I have made a good many studies myself. One of the most perfect and complete of such records is that given by Captain Cadman, before the Annual Poultry Conference held at Harper Adams Cottage, in August, 1923. By his permission I reproduce the results of three curves given by him.

One curve shows the temperature at the hen's body and that underneath the egg, showing the temperature of the hen's body steady at 104°, whilst the bottom temperature starting at 85° rises slowly till at the tenth day it is 100°, falling from the seventeenth day to the twenty-first down to 90°.

The humidity, averaging 45% in the first 10 days, falls to about 25% towards the end.

The carbonic acid remaining about 10 parts in 10,000 up to the tenth day, rises by the fifteenth day to 65-70 parts, and on the nineteenth day to 200 parts, falling again at the end to 70 parts.

The hatch was 100%.

There is the whole story of what nature does. What is the effect of variation of carbonic acid?

The variation can, of course, only be produced in an incubator. But we may turn to the work of the Storrs Experiment Station, Connecticut. By varying the ventilation incubators were run, the carbonic acid rising acccording to the amount to be produced, to certain maxima, which varied from 30 parts in 10,000 to 500 parts in 10,000.

It is shown that up to a maximum of 50 parts in 10,000 the percentage of fertile eggs which hatch is not affected; after that there is a decrease, which, however, is slight until 200 parts is reached, after which there is a rapid decrease.

Carbonic acid has been looked upon too much as a poison; when we realise that the average composition of expired air is 350 parts in 10,000, and that up to 150 parts in 10,000 human beings are not distressed, we shall realise that a wide margin is allowable in this respect.

What is the effect of variations in humidity? The same experimental station tried this, and in a series of tests covering nearly 10,000 eggs, valuable results were obtained as follows:—

From 15% to 20% humidity gave 48% hatches; 20%—30% gave 60.6. This rose till 50%—60% gave 69.3%, which again fell 70%—80%, 45.5%. The best humidity is 50% to 60% and 50% is the safest figure to aim at. It is higher than Cadman got in the hen's nest, it is higher than I have obtained in hens' nests, but the air movement in incubators is greater. The experiments also show the % loss of weight, which was 9.8% at the best humidity. I have already explained that this is not all due to evaporation of moisture, but largely due to loss of carbon. Two more factors are of importance to consider. The hen leaves her nest to feed; the eggs cool; and it has been the practice strongly advocated by many to cool eggs. The same experimenters tried 1,800 eggs cooled in the usual way, and 1,800 not cooled. The results showed that for every 100 eggs not cooled, which hatched, only

96 hatched when cooled. The reason advanced for cooling is that it allows fresh air to be drawn into the egg. Towards the end of the hatch .28 cub. in. of air per minute are required to carry on the life process. The amount which will pass into the air space in cooling from 100 to 90, which is about the range, is trifling and would suffice for a few minutes only. It can have no bearing on the question. It may be that cooling the shell of overdried eggs in certain cases leads to access of moisture to the membrane, and may even weaken the shell by causing minute cracks to form, but the experiments cited negative these suggestions. Moreover, the experience in the Chinese and Egyptian and modern Mammoth incubators is against the necessity.

Turning of eggs is important. The hen is constantly moving them about. The Egyptians attach great importance to turning four times, and experiment has shown a gain up to five turns daily, though perhaps not sufficient to justify the labour.

THE MISSING FACTOR IN ARTIFICIAL INCUBATION.

The measurement and control of moisture and concentration of carbonic acid then arrived at gave much improved and more consistent results, but still the machine lagged behind the hen. This is universally recognised. Breeders who want the highest results always use hens both for high percentage hatchings and for vigorous chicks. Consider the following experimental results by Oregon experimental stations:—

(1) Hatched by hen, mortality at 4 weeks: with hen brooding 2.2%, with artificial brooding 10.8%.

(2) Hatched by incubator, mortality at 4 weeks: hen brooded 49.2%, artificial brooding 33.5%. There is some fundamental difference.

The comparison and measurement in incubators and under the hen disclose one or two important facts. Speaking generally, the average temperature of eggs in an incubator is much more regular than in a hen's nest, particularly if there are a large number of eggs under the hen, but a greater difference was found to arise from the fact that whereas in modern incubators the whole of the egg is nearly at the same temperature, the temperature of the top is only slightly different from the temperature of the bottom. A difference was found in the hen's nest between the temperature of the hen's body in contact with the egg and the temperature of the lower surface of the egg of anything between 14°F and 20°F.

TABLE.

Top and Bottom Temperature in Incubation.

Type.	*Difference between top and bottom of egg.*
1. Mammoth with air circulation ...	nil.
2. Hot air incubator	4°.
3. Hot air tank	4°

5. Hot water tank ... ... 5°
6. Hot water tank with earth floor to nest 7½°
7. Hen's nest ... ... 14°—20°

This suggested the question whether this difference had any biological importance, and at once recalled the studies of Dr. Leonard Hill, F.R.S., on the subject of temperature differences in connexion with human and animal comfort and wellbeing. Dr. Hill has shown conclusively that health and wellbeing depend not only on temperature of the body, but much more on the correct regulation of the cooling power of the air in which a human being or animal is placed, and that a direct measure of correct conditions may be obtained by measurements of the actual rate at which heat can be conveyed from a body placed in any particular condition.

Dr. Hill has devised an instrument known as the Kata thermometer, a thermometer so arranged that by observing the rate at which the bulb cools and the spirit column falls, we may determine the cooling effect of the surroundings. Furthermore, he has determined that there are definite rates of cooling which in sleep, in sedentary conditions, and in full activity give the greatest comfort. He has also shown that circulation and food utilisation (metabolism) are greatly increased by keeping the body temperature up whilst submitting the skin and lungs to cool air, an increase in metabolism up to even 50% being determined in experiments on children.

It seemed possible, particularly having in view that the organ in the egg which absorbs fresh air and expires air that has been used - lies towards the bottom of the egg, and is connected to the embryo by a very complete circulating system, that there might be a biological importance in keeping the upper surface of the egg hot and the lower surface cool.

Several methods were tried with a view to achieving this object, but they generally involved the lower surface in too much ventilation. Finally, the experiment was tried of covering the upper surface of the eggs with a very thin sheet of india-rubber.

In the case of a hot-water tank incubator, in which the heat reaches the egg by radiation, the effect of this was to diminish the heat reaching the eggs to such a point that unless the temperature of the tank was raised to an inconvenient degree they could not be properly warmed; but on modifying a hot air incubator so that the downward stream of hot air instead of passing through the eggs passes on to and across the surface of the rubber, discharging by holes just above the level of the tray, the temperature of this rubber layer being raised to 105°F, the temperature at the bottom remains at about 91°F, a difference of 14°F. Furthermore, the eggs being enclosed, as it were, and the only removal of moisture being by the process of diffusion into the pure air below, the very rapid evaporation was stopped, and measurements showed that the moisture and carbonic acid followed very closely those existing in a hen's nest.

The application of this method produced very remarkable results, and in successive hatches in an incubator which has rarely given above 55% of the eggs placed in it, modified to this plan, this percentage was raised to over 95% of the fertile eggs, being about 89% of all the eggs.

It will be noted that the application of heat to the eggs in this case is by direct contact and conduction instead of by methods of radiation, or alternatively convection, on the types which have been already explained. It is furthermore to be noted it may be that in this condition every egg becomes its own regulator, since there is a supply of heat at the upper surface of the egg passing to the cool under-surface, and should the supply of heat become too great the organism is enabled to regulate the heat by passing this heat through the blood stream to the cooler part.

The great losses from "dead in shell" are put down to all sorts of causes. The chicken dies at the nineteenth or twentieth day, and in nearly every case the yolk, which should have been drawn in, is outside. Why? May it not be that from defective metabolism it has remained too large and cannot be drawn in? May not the losses of incubated chicks be due to the same low metabolism and low vitality of the chick at hatching? Of the chickens hatched by the new method I have indicated, reared indoors on stone and wood floors, I have had no losses except by accident, and in the last lot—hatched from eggs of which 37% were infertile—not a single loss up to four weeks.

The remarkable change in the results obtained on the application of this process has led the writer to believe that this element of differential temperature is in reality the factor which has been missing in artificial incubation.

The limits of time prevent more detailed discussion of this and many other points that might be profitably dealt with. I can only hope that I have been able to give a clear picture and correlation of the physical and biological considerations which form the scientific principles of artificial incubation.

DISCUSSION.

The Chairman, in opening the discussion, said he thought every one would agree that Mr. Atkinson had provided those present with a great deal of food for thought. He had himself listened with very great interest to the question of placing a thin sheet of india-rubber upon the top of the eggs. The most successful incubator he had ever used, so far as the results were concerned in strength of chickens hatched, was in Newcastle 46 years ago. That was the Penman incubator, which attempted to apply actual contact to the upper surface of the egg in the same way as a hen transmitted the heat to the egg. The unfortunate part was that Mr. Penman used a thick layer of india-rubber and ran his hot water over it, with the result that the rubber sagged, and the chickens could not get out. Therefore, a good number of them were wasted; but those that did get out were really wonderful so far as vigour was concerned; and since that time he had been wondering whether there was not more in the question of actual contact than incubator makers and users had hitherto thought. If nothing else had been done—and he would suggest that a great deal more had been done—Mr. Atkinson's introduction of that method, if it could be carried out, and if it proved itself, might help to solve what had been a very great difficulty. They all knew very well, though some, perhaps, did not confess it, that the hen up to the present time had beaten the incubator all the time. He had been in some of the biggest plants in America; he had visited one in California where they had a capacity of 250,000 eggs at a single hatch, and there were bigger ones now. The proprietors would not tell all they knew; that was the trouble amongst poultrymen—they did not announce their failures—but there was no doubt that there was a great weakness in artificial incubation, and poultrymen everywhere were seeking a solution of that problem. It might be that what had been suggested that evening would inaugurate a new era in the poultry industry.

With regard to the Boyle incubator to which he had referred, Mr. Boyle, who was an artist living at Ambleside in Westmorland, and whom he had visited there, had watched the hen most carefully; and if any one could get the old records of that day they were worth reading. Mr. Boyle was all the time under the definite conclusion that to get success in artificial incubation one must keep the bottoms of the eggs a good deal cooler than the top. He was merely copying the hen; and there was no doubt that the hen was worth copying!

LIEUT.-COLONEL F. W. HARDY asked how the extremely good results which the Chinese and the Egyptians succeeded in getting were obtained. He understood that they did not cover their eggs over with rubber sheeting or anything else. How was it that they got the difference in temperature at the top and bottom of the egg; or, at any rate, how was it that they hatched so successfully?

MR. ATKINSON replied that the only thing that could be said against the theory he had put forward—and he quite realised it was a strong point—was the success, not of the Egyptian, but of the Chinese system of incubation, where the heat was put in at the bottom of the incubator. He had no explanation whatever to offer. Of course, he had never seen the chickens hatched by that method; but so far as the Egyptian method was concerned, he would remind those who were interested that the heat was applied from the top. The eggs were in heaps for the first ten days, and, therefore, all the heat that reached the lower ones did reach them by a process of conduction from the top of the egg to the bottom; in other words, the eggs themselves were making the contact layer by layer with the lower ones. There was a definite conduction of heat downwards. He had discussed that question with Captain Cadman, who was quite sure in his own mind, having looked into the question, that there were those differences of temperature in the Egyptian system more than there were in the modern incubator. But the Chinese system he did not profess to bring into line with anything he had in his mind.

MR. ERIC H. PALMER-JONES asked at what temperature the experiments were conducted with the rubber sheeting over the eggs.

MR. ATKINSON said that the actual thermometer hanging in the egg-chamber in the usual position was at 108°; but a thermometer laid on that part of the rubber which was not in contact with the eggs, *i.e.*, in between them—was kept at 105°. That was the temperature of the lower part of the hen. On the top of the rubber the temperature was 105°, and there was about half a degree difference between the upper and lower sides of the rubber.

MR. PALMER-JONES asked whether the eggs were turned.

MR. ATKINSON replied that they were turned in the usual way twice a day.

MR. M. W. SLADE asked what was the idea of having the rubber very thin.

MR. ATKINSON said he had tried the rubber at various thicknesses. He had hatched quite satisfactorily with rubber twice as thick as that he was now using, but it involved having a much higher temperature up above; instead of about half a degree of difference one might get up to two or three degrees of difference between the upper side and the lower side. The objection to that was that as the process of incubation went on, and much less heat was required to be carried down in to the egg (because the egg was producing 60 per cent. of the required heat), a difficulty was found unless one was constantly testing the real temperature underneath—a difficulty as to what temperature to use. Although he personally could work quite well with rubber at least twice as thick as that shown, he thought other people who wanted to have one thermometer and avoid too much trouble found that it was better to have the rubber very thin.

MR. A. HART asked what was the size of the holes in the plate which Mr. Atkinson had shown, and whether the size of the hole bore any relation to the cubic capacity of the egg itself.

MR. ATKINSON said the size of the holes had nothing to do with cubic capacity, because, as a matter of fact, within about ten minutes of the eggs being put in—at least towards the later stages—the normal condition was set up of a flow by diffusion of the gases from above to below. The area of the holes was in fact about one-thirteenth of the area of the plate, and with that one obtained a vapour concentration of about 50 per cent. above when the concentration down below was somewhere about 60 per cent. at 60°. It was carefully calculated to give the right concentration above with the normal air concentration below; but it had nothing to do with the cubic capacity—it had relation to the area.

MR. PALMER-JONES asked what means Mr. Atkinson adopted for heating the incubator.

MR. ATKINSON said that in the particular incubator shown he had taken the heater off because of its weight, but he used an ordinary hot air heater on the side of the usual form.

MR. WILLIAM LOCKEY asked whether it would make any difference whether the heat was supplied from hot water or hot air, and also whether the temperature would be greater with the sheet on or the sheet off. Would a metal plate deflect or reflect the heat back into the rubber sheet, or did it make any difference whether there was a metal plate or a wooden plate at the bottom?

MR. ATKINSON said that when using a hot water tank incubator he had found that he could not get enough heat radiated on to the rubber unless the temperature of the water was raised practically to boiling-point, which was, of course, very inconvenient: it involved a lot of steaming, and it also involved increasing the temperature of the upper part of the incubator, and, therefore, wasting heat. He had found that the method of radiating on to the rubber did not give enough heat, but bringing the air down to it did. With regard to the bottom plate underneath, first of all one could work without that bottom plate; but if one did, one was working then at the earlier stages with air going in, and unless the air was moistened it was too dry, and it evaporated too much moisture from the eggs. Something must be put in to reduce the evaporating area. He had put a metal plate in because what he tried to do all the time was to keep the temperature down; in other words, he wanted a cold surface below the eggs, not a warm wooden one. The wood kept the lower surface of the eggs too hot. There was a cold stream of air, perhaps at 60° going along the metal plate, and it kept the metal plate at somewhere about 70° and that helped to cool the underside of the tray.

Mr. H. E. Watts said he understood that the question of the temperature of the incubator room was not so important under the improved method as it used to be considered; and, further, that there was no necessity for wetting the floor.

Mr. Atkinson said that if the weather was very dry and he were bringing out some big hatches he would be inclined to wet the floor, because at the last day he had got the rubber off, and he might be putting very dry air in, and his experience was that one wanted to keep the air fairly moist. Personally he would wet the floor towards the end of fairly big hatches; but for the rest of the time he did not put any moisture in.

Mr. Slade asked whether Mr. Atkinson had any details as to the necessary humidity of the outer air in his experiments.

Mr. Atkinson said the humidity of his incubator cellar if he did not wet the floor, ran at an average of about 60 or 70 per cent. at 60°. Of course, that came down to about 25 or 30 per cent. by the time it had got to the temperature of the incubator, but in the incubator the current of air below the eggs was never above about 78, so it was not like the air going into an ordinary hot air incubator, which was taken up to 103.

Mr. R. Borlase Matthews said he had had the privilege of being in touch with Mr. Atkinson from time to time right throughout his experiments, and it was wonderful to see the amount of work he had put into them, with the final result of the very valuable paper he had read. Mr. Atkinson had said at the beginning of his paper that the essence of science was measurement, and he had given a very good idea of the measurements required in incubation, opening up a quite new field. He (the speaker) had carried out one or two trifling experiments with his own incubator, which was of the air-circulation type, and he had been able to keep a constant check by means of Mr. Atkinson's little chart of humidity, and the carbon dioxide test certainly showed a little more than the thermometer showed. It seemed to him that by the aid of the rubber sheet one got a comparatively small chamber, which gave an opportunity of applying the heat very much more efficiently. Therefore, it seemed a good opening for electrically heated incubators on the modified basis indicated by the reader of the paper.

Mr. Atkinson agreed that it did open up a great prospect of improvement on the question of heat losses. He had applied the ordinary heater because he did not think it was wise to change too many things at a time. He had some incubators running at present with some new lamp arrangements which had given very satisfactory results. He had saved one-half of the losses by finding out where they took place. The moment one measured, one found where it was worth while cutting down. He had tried lamps which would run a 100 incubator using less than half an ounce of oil per hour instead of one ounce. But in testing a new arrangement like the one he had described he did not like to try to alter too many things at once; it was better to take one thing at a time and see where the changes came from

THE CHAIRMAN asked whether Mr. Atkinson had found any change, so far as the loss of weight was concerned, with his new arrangement. The loss of weight was, of course, very much greater in an artificial incubator than under the hen.

MR. ATKINSON said that he had not actually tried that experiment, but a great many incubator workers, at any rate a few years ago, laid great stress on the gradual growth of the air space in the egg, and they had made great efforts to get it fairly large. As a matter of fact, they had tried to get it large by evaporating the contents of the egg. In nature there was very little change in the size of the air bubble during the first ten days, and his belief was that the direction in which to get it large was not by evaporating a lot of moisture out of the egg, but by producing an intense combustion by good blood circulation, so that the bubble was enlarged by burning up the material in the egg and not by evaporation.

MR. OSCAR BROWN asked whether Mr. Atkinson had done any special work on the incubation of duck eggs. People who were trying to incubate them artificially at present were finding much greater difficulty than in the case of hens' eggs; but Captain Cadman, who took out some ducks to Egypt last year, had found that they got quite good results in the Egyptian egg ovens. He would be very grateful if Mr. Atkinson would give his views on that subject.

MR. ATKINSON said that his experience in the direction referred to was probably different from that of most people. He would go so far as to say that without difficulty, in various types of incubators, he had always been able to hatch every duck egg that was any good. He had been able to hatch turkeys' eggs in incubators much better than hens' eggs. He believed that the reason was that they were larger, and one naturally got a bigger difference between the top and the bottom than one did with the smaller hens' eggs. At any rate, he had never had the difficulty with duck eggs. Of course, the moisture had to be kept up carefully if one was using hot-air incubators.

MR. OSCAR BROWN asked whether Mr. Atkinson had followed any different course, or whether he had used the machines in the same way; because several poultrymen had found that they had had very bad results, but possibly they did not do the thing in the right way.

MR. ATKINSON said that for some two or three years he had adopted the practice of stuffing up every ventilating hole on his incubators for the first ten days, and it might be that that had something to do with his success, because he realised that at that time there were tremendous draughts and evaporations due to the circulation of air. So he always began by blocking up with cotton-wool the holes that the maker had provided; he kept the moisture up, and had for some years measured it. Putting on the moisture during the last four or five days did not moisten the incubator. An ordinary incubator would absorb about twelve pounds of water before it began to raise the real moisture at all. Ordinary incubators were made of wood, and wood absorbed 25 per cent. of its weight of moisture; and if one put on the moisture during the last few days one was merely preparing the incubator for the next hatch.

Rear-Admiral J. de Courcy Hamilton, M.V.O., said he had heard that a thunderstorm was very detrimental to the process of incubation, and he asked whether Mr. Atkinson could give any experience of the matter.

Mr. Atkinson said he had never connected any bad hatch with a thunderstorm.

The Chairman, in proposing a vote of thanks to Mr. Atkinson, said that the suggestions contained in the paper would help in the extension of knowledge. In spite of what had been said about the hen beating the artificial incubator all the time, it was true that the poultry industry had been built up on artificial incubation, and its future depended upon the solution of the problems that arose in connexion with artificial hatching. Therefore, the author, in giving so much thought and time and study to the subject, and in bringing to bear his scientific knowledge, not only in the realm of biology but in physics and mechanics, was rendering a very great service to the industry.

Mr. Atkinson, after returning thanks to the meeting for its reception of his paper, proposed a vote of thanks to the Chairman. There were two reasons why he had suggested to the Secretary that Mr. Edward Brown should be asked to occupy the chair, first, that he was looked upon by many people as the father of the British poultry industry; he had devoted his life to it, and no one could do more; and secondly, he (Mr. Atkinson) had read a statement by Mr. Brown that more failures in the poultry industry were to be attributed to pinning faith on the incubator than to any other single cause. That led him to believe that Mr. Brown would sympathetically receive his efforts to improve the incubator, even if he did not endorse all his opinions.

CORRESPONDENCE.

ELECTRIC VEHICLES.

In the report of my remarks on Colonel Crompton's paper as given on page 22 of the *Royal Society of Arts Journal*, I see that I overlooked an error in the proof in line 15 from the bottom of the page, "where 25 to 30 miles an hour", should have been "25 to 30 miles or more".

With regard to Colonel Crompton's expectation that I would have dealt more with electric vehicles, it seemed so short a time since Messrs. Griffin published my book on Industrial Electric Vehicles and Trucks, that it was not necessary to occupy time on the subject.

W. WORBY BEAUMONT.

COTTON IN ARGENTINA.

Among the countries where the growing of cotton is possible and profitable from a commercial point of view, Argentina stands very high, for, though cotton has been grown there since the days of the American Civil War, if not prior to that date—the first Jesuit Mission being founded there in 1750—it is only during the last few years that the vast possibilities the country possesses have been realised.

As indicating the growth of this industry the following figures are quoted by the *Indian Textile Journal*.—

Season.		Acres under cultivation.
1918-19	..	32,443
1920-21	..	58,934
1922-23	..	56,474
1923-24	..	154,765

It is anticipated—though probably this is an optimistic anticipation—that this year's crop will amount to about 60,000 bales. Growers in Argentina are very enthusiastic and are determined in the near future to rival the output of Brazil which, at present, averages about 500,000 bales per annum. The principal cotton grown is of the type known as Chaco cotton, which is said to compare very favourably with American Upland, and gives a good length fibre classified in Liverpool as equal to fully middling. One of the difficulties encountered is the sparse population. The total population in Argentina is barely six millions, while the country itself is nearly as large as Europe. Not only is the northern portion, which is the most suitable for cotton growing, the least populated, but it is, unfortunately, the district which makes the least appeal to the newly-arrived immigrants, who usually prefer the more temperate middle and southern parts of the country, where cereals can be grown. Another difficulty that has to be faced is that of transport. The majority of the Chaco cotton has to be carted very long distances to the railroad, and then carried by train to Buenos Aires, a distance of about one thousand kilometres—and railway freights are by no means light in Argentina—and this materially adds to the market price of the cotton. This question does not at present seriously prejudice the industry, but should other sources of supply be forthcoming, the problem of competition and the lowering of market charges would make the question of the cost of transport a very serious one. The soil of the cotton-growing areas is practically virgin and has given very good yields, the net yield per acre being 265 lbs. as compared with 100 lbs. in Georgia and 144 lbs. in Louisiana. Competition and rivalry in trade undoubtedly do good, and it must be borne in mind that while Argentina is very enthusiastic, and has very materially increased her cotton output, and will probably continue to increase it, other countries, and, in particular, the country of Brazil just across the border, are equally enthusiastic and can show equally good increases both as regards quantity and quality. In Brazil the total production of cotton in 1921 was 70,000 tons, while in 1922 this had been increased to 115,000 tons. The Argentine Republic cannot, therefore, expect to have things all its own way, but it can reasonably expect a prosperous future in cotton growing.

MEETINGS OF THE SOCIETY.

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ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock, unless otherwise announced :—

DECEMBER 10. (5.0 p.m.).—**NORMAN THOMSON**, "Colombia as a Field for Development." **THOMAS J. IVE**, Vice-President of the Anglo-Colombian Chamber of Commerce, will preside.

THURSDAY, DECEMBER 11.—Senatore Guglielmo Marconi, G.C.V.O., LL.D., D.Sc., Chairman's Inaugural Address, "Radio Communications."

PAPERS TO BE READ AFTER CHRISTMAS.

SIR ERNEST RUTHERFORD, M.A., D.Sc., F.R.S., *Trueman Wood Lecture.*

SIR J. FORTESCUE FLANNERY, Bt., Past-President of the Institute of Marine Engineers, " The Diesel Engine in Navigation." LORD BEARSTED will preside.

SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., " The Power of Internal Combustion Engines for Motor Cars."

MAJOR-GENERAL SIR WILLIAM SEFTON BRANCKER, K.C.B., Director of Civil Aviation, Air Ministry, " Commercial Aviation."

HENRY G. DOWLING, " Wall-papers."

CLAUDE H. FRIESE-GREENE, " Colour Cinematography."

J. S. OWENS, M.D., A.M.I.C.E., F.G.S., Superintendent Advisory Committee on Atmospheric Pollution, Air Ministry, Meteorological Office, " Modern Atmospheric Conditions."

SIR SAMUEL INSTONE, " The Thames Passenger Services."

CEDRIC CHIVERS, " Bookbinding."

PROFESSOR W. E. S. TURNER, O.B.E., D.Sc., F.Inst.P., Department of Glass Technology, University of Sheffield, " The Modern Production of Sheet-glass."

C. R. PEERS, C.B.E., F.S.A., Chief Inspector of Ancient Monuments and Historic Buildings. Subject to be announced later.

LIEUT.-COLONEL ANDREW BALFOUR, C.B., C.M.G., M.D. (Edin.), B.Sc., D.P.H., F.R.C.P.E., " The Trend of Modern Hygiene."

MRS. GRAYDON-STANNUS, " Irish Glass, Old and New."

CHARLES A. BAKER, Engineering Department, London County Council, " The Electrical Equipment of the London County Hall."

EMILE CAMMAERTS, " The Restoration of Public Buildings in Belgium."

LIEUT.-COLONEL SIR DAVID PRAIN, I.M.S., C.M.G., C.I.E., M.A., LL.D., F.R.S.E., F.R.S., *Sir George Birdwood Memorial Lecture,* " Government Botanical Gardens."

J. T. MARTEN, M.A., I.C.S., " The Indian Census."

SIR HENRY SHARP, C.S.I., C.I.E., M.A., " The Development of Indian Universities."

SIR GILBERT T. WALKER, C.S.I., M.A., F.R.A.S., Sc.D., Ph.D., F.R.S., " Indian Meteorology."

BRIGADIER-GENERAL SIR PERCY M. SYKES, K.C.I.E., C.B., C.M.G., " The Heart of Asia and the Roof of the World."

SIR ALFRED CHATTERTON, C.I.E., Assoc.M.Inst.C.E. Subject to be announced later.

LORD STEVENSON, G.C.M.G., " The British Empire Exhibition, 1924."

HON. WILLIAM G. A. ORMSBY-GORE, M.P. Subject to be announced later.

LORD BLYTH, " Penny Postage and Postal Communications Generally."

R. H. BRACKENBURY, " Transport in Tropical Africa."

CANTOR LECTURES.

Monday evenings, at 8 o'clock.

Louis C. Martin, D.I.C., A.R.C.S., D.Sc., Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and Technology, South Kensington, " Modern Colour Problems." Three Lectures. November 24, December 1 and 8.

Lecture III.—Colours of material objects. Some colorimeters and their possible accuracy. Limited range colorimeters and nephelometers. General lines of progress. Probable limitations of these methods.

V. E. Pullen, Director, Radiological Research Department, Woolwich, " Radiological Research—A History." Three Lectures. January 19, 26, February 2.

Lecture I.—Natural Philosophy. The Fascination of speculative philosophy. The border line between science and philosophy. Early natural philosophy. Development of theory. Discovery of X-rays. Controversy as to their nature. Modern theory concerning X-rays. Relation to modern atomic theory.

Lecture II.—Early apparatus. Early X-ray generators. Early vacuum tubes. X-ray tubes. Development of electrical generators. Development of X-ray tubes. The X-ray spectrometer. Measuring apparatus. Lines of modern radiological research.

Lecture III.—Early applications of X-rays. Development of medical uses. Modern applications. Physiological dangers. Necessity for protection.

Walter Rosenhain, B.A., B.C.E., D.Sc., F.R.S., Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory, " The Inner Structure of Alloys." Three Lectures. February 16, 23, March 2.

HOWARD LECTURES.

Professor John Samuel Strafford Brame, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, " Motor Fuels." Three Lectures. April 20, 27, May 4.

DR. MANN JUVENILE LECTURES.

Wednesday afternoons, at 3 o'clock.

Lieut.-Colonel E. H. Richardson. Two Lectures.

Lecture I.—January 7.—" Dogs in War."
Lecture II.—January 14.—" Dogs in Peace."

(Special tickets are required for the Dr. Mann Juvenile Lectures.)

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

Monday, December 8..Surveyors' Institution, 12, Great George Street, S.W. 8 p.m.

Geographical Society, Lowther Lodge, Kensington Gore, S.W. 5 p.m. (Informal Meeting).

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 7 p.m. (Informal Meeting.) Mr. G. M. Clark, "The Pretoria Power Station."

Farmers' Club, at the Royal United Service Institution, Whitehall, S.W. 6 p.m. Prof. J. B. Buxton, "Is it advisable that the Tuberculosis Order of 1914 or some Amendment thereof should be made operative?"

Metals, Institute of (Scottish Section), 39, Elmbank Crescent, Glasgow. 7.30 p.m. Mr. S. E. Flack, "Ships' Propellers."

Brewing, Institute of (London Section), at the Engineers' Club, 39, Coventry Street, W.C. 7.30 p.m. (1) Annual General Meeting. (2) Messrs. H. F. E. Hulton and J. L. Baker, "The Removal of Nitrogen from Wort by Yeast during Brewery Fermentation."

University of London, King's College, Strand, W.C. 5.30 p.m. Dr. R. W. Seton-Watson, "Austria-Hungary, 1867-1918." (Lecture X.)

Embroiderers' Guild, at the Victoria and Albert Museum, South Kensington, S.W. 3 p.m. Prof. Lethaby, "Design."

Victoria Institute, Central Buildings, Westminster, S.W. 4.30 p.m. Prof. T. G. Pinches, "The Worship of Idols in Assyrian History in relation to Bible References."

Tuesday, December 9..Automobile Engineers, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 7 p.m.

Anthropological Institute, 50, Great Russell Street, W.C. 8.15 p.m.

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C. 8.30 p.m. Viscount Willingdon, "Thoughts on India."

Marine Engineers, Institute of, 85, The Minories, E. 6.30 p.m. Mr. J. C. M. MacLagan, "The Sliding Cylinder double-acting two-cycle Diesel Engine."

Mechanical Engineers, Institution of (South Wales Branch), Chamber of Commerce, Swansea. 6 p.m. Mr. D. Adamson, "Economics and Engineering."

Faraday Society, at the Chemical Society, Burlington House, Piccadilly, W. 7.30 p.m. (1) Dr. D. J. Hissink, "Base Exchange in Soils." (2) Professor N. M. Comber, "The Role of the Electro-Negative Ions in the Reaction between Soils and Electrolytes." (3) Messrs. H. J. Page and W. Williams, "Studies on Base Exchange in Rothamsted Soils." (4) Prof. G. W. Robinson and Mr. Rice Williams, "Base Exchange in Relation to Soil Acidity." (5) Mr. S. J. Saint, "The Relation between the pH Value, the Lime Requirement and the Thiocyanate Colour of Soils." (6) Mr. E. A. Fisher, "Some Secondary Aspects of Base Exchange in Soils."

Electrical Engineers, Institution of (E. Midland Centre), at the Town Hall, Leicester. 6.45 p.m. Mr. T. Hall, "Domestic Applications of Electricity."

University of London, King's College, Strand, W.C. 5.30 p.m. Baron A. F. Meyendorff, "The Theoretical Interpretation of Marxism in Russia."

5.30 p.m. Mr. M. Kaye, "The Philosophy of the Absolute in English Thought." (Lecture I.)

Photographic Society, 35, Russell Square, W.C. 7 p.m. Conference of the Scientific and Technical Group on the Standardisation of Methods of Testing Dry Plates.

Wednesday, December 10..Constructive Birth Control, Society for, Essex Hall, Essex Street, Strand, W.C. 8 p.m. Miss E. F. Rathbone, "Family Endowment and Birth Control."

University of London, University College, Gower Street, W.C. 5.30 p.m. Mr. I. Björkhagen, "Fredrika Bremer and England." (Lecture I.)

5.30 p.m. Mr. A. Gomme, "Technical and Scientific Libraries."

Public Health, Royal Institute of, 37, Russell Square, W.C. 4 p.m. Sir Robert Jones, "The Problem of the Cripple Child."

Civil Engineers, Institution of, Great George Street, S.W. 7 p.m. (Informal Meeting.) Mr. E. Latham, "Suitable Fendering for Tidal Berths."

Thursday, December 11..African Society, at the Royal Society of Arts, John Street, Adelphi, W.C. 5 p.m.

Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p.m.

Textile Institute, 38, Bloomsbury Square, W.C. 7 p.m. (Informal Meeting.)

Historical Society, 22, Russell Square, W.C. 5 p.m. Prof. F. H. Relf, "Elsing's Note Book, 1628."

London County Council, Geffrye Museum, Kingsland Road, E. 7.30 p.m. Sir Frank Baines, "Westminster Hall."

Metals, Institute of, at the Institute of Marine Engineers, 85, The Minories, E. 7.30 p.m. Mr. F. W. Rowe, "Present Problems and Developments in Engineering Bronze Foundry Practice."

Electrical Engineers, Institution of (Dundee Centre), University College, Dundee. 7.30 p.m. Messrs. A. G. Norris and Mr. W. H. T. Swire, "Industrial Power Supply. A comparison of Electrical and other Methods of Driving Industrial Machinery."

Mechanical Engineers, Institution of (Midland Section), Queen's Hotel, Birmingham. 6.30 p.m. Eng. Vice-Admiral Sir George Goodwin, "The Trend of Development of Marine Propelling Machinery." (Thomas Hawksley Lecture.)

University of London, King's College, Strand, W.C. 5.30 p.m. Mr. M. Beza, "Pagan Remnants of Roumanian Folklore." (Lecture II.)

5.15 p.m. Rev. W. R. Matthews, "The Social and Political Ideas of some Great Thinkers of the Renaissance and Reformation." (Lecture VIII. "John Calvin.")

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Joint Meeting with the Mechanical, Electrical and other Engineering Institutions who are co-operating in Tabulating the Results of Heat-Engine and Boiler Trials. Discussion on a paper by Captain H. R. Sankey, "Standards of Comparison in Connection with the Thermal Efficiency of Steam Engines."

Friday, December 12..London Society, at the Royal Society of Arts, John Street, Adelphi, W.C. 5 p.m. Major H. Barnes, "The Bridges of London."

Astronomical Society, Burlington House, Piccadilly, W. 5 p.m.

Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W. 6 p.m.

Metals, Institute of (Swansea Section), University College, Singleton Park, Swansea. 7.15 p.m. Mr. T. Hill, "The Design of Furnaces for Annealing and Heat Treatment."

Mechanical Engineers, Institution of (Yorkshire Branch), in the Philosophical Hall, Park Row, Leeds, 7.30 p.m. Prof. G. P. Charnock, "Some Fallacies concerning Invention."

University of London and Shakespeare Association, King's College, Strand, W.C. 5.30 p.m. Dr. E. Grillo, "Shakespeare in Italy."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. A. Cheese, "A Winter Holiday in Greece."

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FRIDAY, DECEMBER 12, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

CANTOR LECTURE.

On MONDAY, DECEMBER 1st, DR. LOUIS C. MARTIN, A.R.C.S., D.Sc., Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and Technology, South Kensington, delivered the second lecture of his course on "Modern Colour Problems."

The lectures will be published in the *Journal* during the Christmas recess.

FOURTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 3rd, 1924. SIR ROBERT ABBOTT HADFIELD, Bt., D.Sc., F.R.S., Member of the Council, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Field, Major George Kenelm, London.
Mullowney, John James, M.D., Nashville, Tennessee, U.S.A.
Shuttleworth, Alfred, Bury, Lancs.

The following candidates were duly elected Fellows of the Society:—

Bahri, Hakim Roy, B.Com., Delhi, India.
Barton, Sir William, J.P., Stockport.
Burrell, William Gunn, M.A., Glasgow.
Clinton, William Wills, London.
Fairey, C. R., M.B.E., F.R.Ae.S., Hayes, Middlesex.
Horning, Harry Le-Van, Waukesha, Wisconsin U.S.A.
Minns, Miss Susan, Boston, U.S.A.
Pountney, Harold W., London.
Rothwell, Charles Frederick Seymour, Radlett, Herts.

A paper on "The Teaching of Science in Secondary Schools" was read by PROFESSOR C. A. CARUS-WILSON, M.A., F.R.A.S.

The paper and discussion will be published in the *Journal* of December 26th.

INDIAN SECTION.

Friday, December 5th, 1924; Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., in the Chair.

A paper on "Problems of Food, with Special Reference to India," was read by Lieut.-Colonel R. McCarrison, C.I.E., M.D., LL.D., D.Sc., F.R.C.P., Indian Medical Service.

The following took part in the discussion:—Sir William Henry Willcox, K.C.I.E., C.B., C.M.G., M.D., Lieut.-Colonel Sir Charles H. Bedford, D.C.L., LL.D., D.Sc., M.D., late I.M.S., Colonel W. G. King, C.I.E., M.B., late I.M.S., Colonel Sir Charles E. Yate, Bt., C.S.I., C.M.G., Mr. N. M. Muzumdar, Dr. C. Muthu, General Sir Edmund Barrow, G.C.B., G.C.S.I., and Dr. J. Augustus Voelcker, M.A.

The paper and discussion will be published in the *Journal* of January 2nd, 1925.

DR. MANN JUVENILE LECTURES.

Under the Dr. Mann Trust a short course of lectures adapted to a juvenile audience will be delivered on Wednesday afternoons, 7th and 14th January, 1925, at 3 p.m., by Lieut.-Colonel E. H. Richardson, on "Dogs in War" and "Dogs in Peace." The lectures will be fully illustrated with lantern slides, and by the dogs themselves.

Special tickets are required for this set of lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to tickets admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

Tea and coffee will be served in the Library after the lectures.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

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THIRD ORDINARY MEETING.

Wednesday, November 26th, 1924.

Mr. Alan A. Campbell Swinton, F.R.S. (late Chairman of the Council), in the Chair.

The Chairman, in introducing the reader of the paper, said Mr. Elwell, who was about to give a demonstration of Talking Motion Pictures, was very well known in the electrical world, more especially in connexion with wireless telegraphy.

He had probably done more than any one else in the production of what were known as continuous wave stations by means of the Poulsen arc. He was one of the pioneers in that particular line, and apparently he had now started on another pioneering expedition, about which he would tell the meeting on that occasion.

The paper read was:—

DE FOREST PHONOFILMS OR TALKING MOTION PICTURES.

By C. F. Elwell, B.A., M.I.E.E.

Many inventors have tried during the last two decades to solve the problem of making perfectly synchronised talking motion pictures. The first "talking picture" was known as the "Cameraphone"—the method employed being to make the motion picture while a stock wax cylinder type of record was played. The actors sang, or pretended to sing, and the camera photographed the lip motion. The novelty of this method made it popular for a time.

The "Kinetophone" of Thomas A. Edison was the next step in advance. Better results were obtained for the reason that the phonograph record was made simultaneously with the making of the motion picture negative. The synchronisation of the sounds with the lip motion was good, but the reproduction of this synchronisation was difficult, as so much depended upon the skill of the operator, who generally had another man to start the phonograph record. If mechanical or electrical means were supplied it was difficult to keep the phonograph record and the film exactly in step. If a portion of the film became mutilated the difficulties became greater. Notwithstanding these objections the "Kinetophone" enjoyed quite a large measure of popularity. But this popularity waned, and finally no more was heard of this method. Other inventors tried to perfect Edison's method, but it could not be said that the idea of synchronising a wax sound record with an ordinary film was scientifically very sound. Wireless, among other boons, has made the perfectly synchronised talking motion picture possible upon sound scientific and commercial lines.

When Dr. Lee De Forest, the well-known American wireless inventor, placed a third electrode in the two-electrode valve, he made a discovery which revolutionised the transmission, both with and without wires, of speech and music. This little Aladdin's lamp has made possible radio telegraphy and telephony to the ends of the earth; it has made telephony over wires and cables practicable over distances of 5,000 miles or more; it has made sounds audible which hitherto were quite inaudible and unintelligible, and it has made possible the dream of many years, the perfectly synchronised talking motion picture. It is my intention to explain to you this evening how the three-electrode valve has made possible the talking motion pictures, which will be shown to you on the termination of my remarks. In these examples you will note the perfect synchronisation of the words of the speakers with the motion of their lips, as well as the faithfulness of reproduction of the voices. You will also be given an opportunity of noting the faithfulness of reproduction of music and of song.

Dr. De Forest conceived the idea of making talking moving pictures or "phonofilms," as he calls them, quite a number of years ago. It was only recently that he attacked the problem, and he then laid down as a first essential to the commercial success of these "phonofilms" that only standard film as used in the cinema, should be employed. On a narrow strip, only 3/32" wide, he has succeeded in recording all kinds of sounds. The balance of the width of the film, which, as you know is 1" in width, is used for the picture in the ordinary way. For your enlightenment you will be permitted to see the sound record on the second reel of films. You will see that the very narrow sound record, which will be magnified until it is about 12" in width on the screen, is marked with a varying number of light and dark horizontal lines of different widths. If a high pitched note is being played you will note the large number of fine lines, indicating a high frequency. If a low pitched note is being played or sung, you will observe that the horizontal lines become thicker and there are fewer of them, indicating a low frequency.

How is sound as represented by these lines *recorded* upon this narrow strip of celluloid? In reality it is all very simple, with the aid of the three-electrode valve. The picture is taken in the ordinary way by means of the ordinary cinema camera. In the camera a small gas-filled lamp is placed. The sounds emitted by the speaker are picked up by means of a very sensitive microphone. The very small electric currents from the microphone are amplified enormously by means of a three-electrode valve amplifier. This is done in order that the variations of the electric currents, which represent the sounds made before the microphone, shall be large enough to affect the light emitted by the lamp in the camera. The light from this gas-filled lamp passes through a very fine slit placed as close as possible to the celluloid film. The variations of the intensity of the light from this lamp are recorded photographically on the film in the form of these horizontal lines. The picture and sound have thus been recorded simultaneously and upon the same film. Synchronisation must therefore be perfect. Sound waves have been transformed into electric currents and electric currents into light, which has been permanently recorded upon the sensitised celluloid film. This film is then developed and is known as the negative. From this negative any number of positive prints can be made.

The *reproduction* of the photographically recorded sounds is also very simple. The roll of positive film is placed in an ordinary cinema projector, to which has been fitted an attachment containing a small incandescent lamp, a fine slit which is only .0015" wide and 3/32" long, a guide for the film and a photo-electric cell. The light from the small incandescent lamp shines through the fine slit. The film is guided so that the portion of the film upon which the sound is recorded passes before this illuminated slit. The intensity of the light which passes through the more or less translucent film is governed by the number and width of the horizontal lines. This fluctuating beam of light then falls upon the photo-electric cell. It is the property of a photo-electric cell that its resistance changes with the intensity of the light falling upon it. For talking motion picture work it is essential that these changes should be instantaneous. The Thalofide photo-electric cell, invented by Mr. T. W. Case, is in effect practically instantaneous in its action. The fluctuating beam of light is thus transformed into small electric currents. By means of the three electrode valve these small currents are again increased in strength, until they are strong enough to operate a loud speaker. You will be hearing the loud speaker, and it is for you to judge whether the voice has been faithfully reproduced. Remember that the sound has made a long journey through the air; a microphone; a set of three-electrode valves; a gas-filled lamp; a fine slit; a celluloid film and a photographic bath, which is the cycle necessary to make what is known as the negative. From this negative a positive print was made and developed. Then the second cycle necessary to reproduce consists of a beam of light; a fine slit; a fast moving film; a photo-electric cell; an amplifier and finally a loud speaker, which is perhaps the weakest link in the chain.

Having now briefly described what I believe will impress you as an amazing scientific conquest, when you see and hear, *e.g.*, the President of the United States speaking in the grounds of the White House at Washington, together with other examples of what has been made possible by the genius of Dr. De Forest, a few words as to the possible applications of this invention may be appropriate.

Doubtless it has been passing through your mind that the public may not want the talking picture. Can the picture and sound which go together so naturally in actual life, and which have been so completely divorced from each other since the beginning of the cinema art, and for a good reason, be again brought together in a manner which shall be, if not entirely natural, at least artistic, pleasing, and of educational value?

The ordinary silent drama, to which we have all become so accustomed, will not in general be improved by the addition of the voice. Many moving picture artists have no adequate speaking voices because they have not been trained on the stage. The situation is exactly like that which existed when the motion picture was first evolved. It was the common idea that the motion picture drama would be nothing more than an attempt to photograph the ordinary drama of the stage, limited to the same confined situations, the same small scenes, the same few characters. It did not take long to demonstrate the total failure of the new moving picture art to enter into successful competition with the drama along these lines. An entirely novel type of dramatic scheme and presentation was necessary before screen versions were artistically possible. But Edison and the other moving picture pioneers had supplied a new medium, and the more enterprising, energetic and progressive producers promptly saw the entirely new possibilities which thus lay open to them, and evolved an entirely new form of entertainment. How well they succeeded is attested by the immense moving picture industry of to-day.

Because of the invention of the "phonofilm" an entirely new form of screen drama can now be worked out, taking advantage of the possibilities of introducing music and voice and appropriate acoustic effects, not necessarily throughout the entire action, but here and there, where the effect can be made most effective. It is incumbent upon the scenario writers to see these possibilities and to work up their situations and scenes around such acoustic effects as can be successfully brought out.

It should be possible in the very near future to reproduce in an artistic and pleasing manner, both musically and pictorially, operettas, entire acts of opera, selections by symphony orchestras, popular bands, the songs of concert singers whom the public admire, but are seldom privileged to actually hear, the playing of famous virtuosos, etc.

The addition of incidental music, provided by means of adequate orchestras, to existing films is now possible, and this alone must make for greater enjoyment of silent films by dwellers in the small towns who are now denied adequate musical accompaniment.

The reading of lengthy letters, telegrams, etc., could frequently be far more effectively rendered by a clear resonant voice, and create more dramatic effects than the present system of written communications.

The educational possibilities should by no means be overlooked, as the addition of a lucid explanation, delivered in the first place by some authority on the subject, would greatly enhance the interest to the audience and the lucidity of the lesson to be conveyed.

The weekly news items, which are now so popular, can be made vastly more interesting. The animated cartoons can be made a great deal more humorous if the animals and manikins could speak their funny thoughts.

The filming of notable characters in the public eye will be made much more interesting and genuine to the audience. You will be convinced of this when you hear President Coolidge delivering his talk.

No one can deny the need, to our present more or less thoughtless generation, of frequently seeing and hearing in their exalted moments our really great men, reproduced from time to time for the benefit and uplift and inspiration of us all.

In conclusion, may I ask you not to judge the future usefulness of the De Forest Phonofilm by this present accomplishment, but rather by its promise of finer things soon to be achieved?

Mr. Elwell then gave a demonstration of the talking motion pictures.

THE CHAIRMAN said he was sure every one present would wish to congratulate Mr. Elwell upon the success of his demonstration, which he understood was the first demonstration of that really marvellous invention that had been made in this country. It was difficult to surmise what would be the future of the invention. Mr. Elwell had alluded to those gentlemen who at present appeared in the "pictures," as they were called, who could not speak. He supposed they would all have to take lessons in elocution, because he was sure the public having had such speaking pictures would continue to want speaking pictures; but he dared say there might also be scope for the other kind of picture in scenic effects, where the speaking and sound were not so important. Most professional men had had their mouths made to water when they read in the papers of the fabulous salaries which the picture "stars" obtained. When they had to speak in addition, he supposed they would require an extra fee! The invention which Mr. Elwell had demonstrated was really a very interesting example of how discoveries and inventions in one branch of applied science led to improvements in other branches. The whole of the demonstration, so far as the sound was concerned, depended upon the thermionic valve, which was originally invented in England by an old friend of the Society, Dr. J. A. Fleming, and was afterwards made into a magnifier of sound—an amplifier, as it was called—by Mr. De Forest, who, he believed, was responsible in large measure for the wonderful invention which had just been demonstrated. If it had not been for the invention of that amplifier there would still be the sounds from the film, but the sound would be so weak that it would not be audible even to the slightest extent with the telephone receiver held to the ear; yet those very small electric currents, so small that they would not work an ordinary telephone—and an ordinary telephone was a very sensitive instrument—were magnified by the thermionic valve, and one got the marvellous effects they had heard, which perhaps erred in the direction of being too loud for the size of that room.

MR. ROBERT W. PAUL said he had not come to the meeting to make any remarks, but to learn; and he must say he had learnt a good deal by watching the process illustrated on the screen. It was very difficult indeed to prophesy with regard to the future of any such invention; but when one went back some 30 years and recalled the early moving pictures, and the prophecy by the leading impresario of the day in London of their end in a fortnight; and when one considered the present position of the moving picture in public estimation, and the possibilities that arose out of the invention which had been shown, one could set no limit to their development. As the Chairman had said, it was an example of development in one branch of physics leading to development in another branch—a process which they had all watched in their lifetime as applied to many other things. He could only offer his sincere congratulations to the inventor and to Mr. Elwell, who had just given a very happy demonstration.

SIR RICHARD PAGET, Bt., said that any observations he might usefully make would refer rather to the reproduction of the sound than to any other feature of the demonstration. As the lecturer had said, undoubtedly the loud speaker was the weakest link in the chain; but he had no doubt that even with the means at present available, as for example the pleated disk type of loud speakers, more perfect reproduction could be got. So far as the general synchronisation went, it was extraordinarily good, and seemed hardly capable of being improved. He would only like to add his personal congratulations to those which had already been expressed by Mr. Paul.

Mr. Llewelyn B. Atkinson (Past President of the Institution of Electrical Engineers) said he feared he could not speak as an expert in the art which had been put before the meeting. In that room during the last forty years he had assisted at demonstrations of the present kind in nearly all those arts which had gone to build up what had been presented that evening. He remembered, for instance, Captain Abney giving demonstrations of the early gelatine-bromide photography, which had made possible rapid photography and the sort of photography necessary for motion pictures. He remembered the early phonograph of Edison, the tin-foil gramophone or recording phonograph as it was called, which Colonel Gouraud had demonstrated in that room. He could not remember at the moment whether it was Sir William Preece or Sir Frederick Bramwell, both of whom were closely associated with the Royal Society of Arts, who demonstrated in that room some of the earliest telephones that he and London saw. He remembered in that room Professor Hughes with the microphone in its earlier forms again blinding them with the light of the new forces and the new experiments he had shown. He might go further over the various points that had been shown there—Senatore Marconi, for instance, with his wireless telegraphy. All those were steps towards what had been produced that night, and he congratulated Mr. Elwell on having given such a very successful first demonstration in England of the new process. He did not know which for the moment would most interest him—whether it was the further scientific developments of that art, or to hear the thoughts, expressed in words, of "Felix the Cat!"

Mr. C. H. Friese-Greene said from what he had seen that evening he certainly thought there were wonderful chances for the success of motion pictures in so far as talking was concerned for certain subjects; and he wished to congratulate Mr. Elwell on his very interesting demonstration.

Mr. Charles R. Darling said he had very little to say except to add his congratulations to those of previous speakers to Mr. Elwell for the demonstration he had given. He had looked very carefully to see whether the motions exactly synchronised with the sound; and he had been unable to detect any difference whatever. The method seemed to him to be excellent. He thought he could predict a time when scientific lectures might be shown in that way. There was a possibility that the experiments might be shown, and the lecturer might be speaking at the same time; and in that way the very best lecturers might be made to give their lectures to audiences all over the world. To his mind there appeared to be a very great future indeed for the process demonstrated by Mr. Elwell, and he was sure all would wish that it would meet with every success.

Major Basil Binyon, O.B.E., said there was one thing that had not been mentioned by previous speakers which struck him from the wireless point of view, viz., the really very wonderful and extraordinary degree of low frequency amplification which Mr. Elwell had been able to carry out from those extremely feeble currents which he got from his photo-electric cells. Every one knew in wireless that a large number of stages of low frequency magnification produced a great many technical difficulties, and he thought the inventors of the system shown had to be very warmly congratulated upon being able to produce such a large volume of sound from such exceedingly small currents. He would like to ask Mr. Elwell just one question, whether in any of the films he had shown that night any sections or joins or pieces of spoilt film had been cut out, and if so whether they were an inch or two or any more; because he had not been able to notice anything of that sort. Mr. Elwell had referred in his paper to the fact that if the film was broken accidentally the synchronisation would not be disturbed, but it was possible to join the film again; and he wondered whether cutting out one or two pictures or a note or a portion of a syllable, or even less would make any difference, and whether that had been done in any of the films shown. The only thing which did strike him—and it had been mentioned to him by a friend during the demonstration—was that possibly there was a certain lack of reality. It might be that with that extraordinary achievement, when one got speech in conjunction with a human being on the screen, one expected something more; we might expect, perhaps, a stereoscopic effect, or colour; and we might have one day, as the art advanced, the natural colour stereoscopically with a speaking film—which would be probably absolutely the last word in what it was possible to do in that direction. But he would not like to prophesy on that point.

Mr. Elwell, in reply, said that so far as he knew no pieces had been cut out of these films, but in his experience a small portion of film missing was very hard to detect. As all those who had discussed the film had refrained from severe criticism he was very grateful. He would ask the members to realise that those who were developing the method must crawl before they could walk. The improvement in the art, even in one year, had been enormous. He now had the equipment in England necessary to make pictures, and he hoped to be making next year real all-British pictures.

The Chairman, in proposing a hearty vote of thanks to Mr. Elwell, said that he was sure the meeting would wish to accord to the lecturer a most cordial vote of thanks for his demonstration was really quite an epoch-making one. In the future, instead of all the politicians making speeches all over the country, they would do as Mr. Coolidge had done, as Mr. Elwell had shown, and make their speeches in their back gardens; and the speech and gestures of the politicians would be shown in every village hall throughout the country—a terrible thought!

The vote of thanks was carried unanimously.

OBITUARY.

John Slater, F.R.I.B.A.—The Society has lost a good friend by the death of Mr. John Slater, which took place at his residence in West Hampstead, on December 1st, at the age of 77.

Mr. Slater was born in 1847, at Bishop's Stortford. After being educated at the Collegiate School of his native town and at University College, London, he was articled to the late Professor T. Roger Smith, with whom he collaborated in writing a work on "Classic and Early Christian Architecture." He began to practise as an architect in London in 1873. He was for many years surveyor to the Berners Estate in London, of which he wrote a short history. He himself designed electric lighting stations at Kensington, Notting Hill, and Hove, factories at Chiswick and Hendon, business premises in Oxford Street, and a house at

Kensington Court; while in collaboration with Mr. J. M. Keith and Mr. J. A. Slater, he designed various houses, shops and a factory in and near the Berners Estate. He was President of the Architectural Association in 1887, and Vice-President of the Royal Institution of British Architects from 1900-4.

A man of extremely sound and careful judgment Mr. Slater was greatly in demand as an arbitrator in important building disputes, and he was a member of the Tribunal of Appeal under the London Building Acts.

Mr. Slater joined the Royal Society of Arts in 1891. In 1913 he was elected a member of the Council, on which he continued to sit, with a few short intervals, until the time of his death. He was always ready to place his wide experience at the service of the Society, and he rendered special assistance to the Council with advice and practical help while the renovations to the Society's House were being carried on. At the first Ordinary Meeting after the reopening of the House, he read a paper on "The Strand and the Adelphi," in which he gave an exceedingly interesting account of the region in which the Society had just succeeded in establishing itself on a permanent footing by purchasing the freehold of this House.

In 1914, the Council appointed Mr. Slater to represent the Society on the Chadwick Trust, and in 1923 they also nominated him to serve on the Sir John Soane Museum Trust.

NOTES ON BOOKS.

THOMAS CHIPPENDALE: A STUDY OF HIS LIFE, WORK AND INFLUENCE. By Oliver Brackett. London: Hodder and Stoughton, Ltd. £2 2s. net.

It is remarkable that we possess so little definite information concerning one whose name has become a household word throughout the country. "Hardly anything is known of his personal history," says the "Dictionary of National Biography," which dismisses him in a little more than half a column; and yet it adds: "his influence is attested by the fact that almost all mahogany furniture of the last century is nowadays referred to by the ignorant as 'Chippendale.'" Such general want of information concerning "this elusive personality," as Mr. Brackett calls him, is the more remarkable because Chippendale must have been a very busy man, and moved about among all classes of society. In spite of this, says Mr. Brackett, "gossip has nothing to say about him. Even that notorious busybody, Horace Walpole, has no remarks to make on the subject nor anecdotes to relate, though he and Chippendale were members of the Society of Arts at the same time."

What few facts have come to light about him are carefully set forth by Mr. Brackett, and the most important of these are summarised in a table on pages 15 and 16 of this volume. To readers of this *Journal* probably the most interesting entry is the fact that in 1760 he was elected a member of the Society of Arts, being proposed by Sir Thomas Robinson, of Rokeby, in Yorkshire, who was "at one time Governor of Barbados, and well known as an amateur architect and an extravagant entertainer." At that period a book was kept containing the signatures of members of the Society, and the page on which is the signature of Chippendale contains also the names of Robert Adam, Cipriani, the Duke of Portland, Lord Pembroke and Horace Walpole.

Mr. Brackett gives an extremely interesting account of the various steps in connexion with the publication of Chippendale's famous work, "The Gentleman and Cabinet-maker's Director." In accordance with the common custom of the time, the support of the public was sought before publication by securing advance subscriptions. In the case of an expensive work like this it was necessary to ensure a large number of patrons, and in this Chippendale was extraordinarily successful. Not only did he secure a number of distinguished and wealthy noblemen, but the list contained also numbers of "cabinet-makers, carvers, carpenters, joiners and upholsterers, men of such varied professions as plasterers, engravers, booksellers, a bricklayer, a founder, a painter, an architect, a merchant, a watch-maker, a chemist, an organ-grinder and two professors of philosophy." Mr. Brackett, who thinks that Chippendale understood the art of advertising almost as well as the art of furniture making, remarks that it would be interesting to know "what inducement Chippendale offered to men of the artisan class to subscribe for such a book as 'The Director'."

The second part of the book under notice consists of some sixty excellent plates, showing specimens of Chippendale's masterpieces. These are arranged chronologically, and illustrate his development through the three periods into which Mr. Brackett divides his work, viz.:—

First period (about 1740-1754).	Early Georgian.
Second period (about 1754-1765).	The *Director* period, illustrating the progress of the Rococo, Gothic and Chinese fashions
Third period (about 1765-1779).	Work executed under the influence of Robert Adam, painting, lacquer and inlay being the most favoured forms of decoration.

In a series of appendices are printed Chippendale's accounts for the furnishing of Nostell Priory, Mersham Hatch, David Garrick's House in the Adelphi, and Harewood House. These are extraordinarily interesting from the economic point of view. They are given in great detail and the prices are such that often one can hardly believe that any profit could have been made on the articles. The well-known "Diana and Minerva" commode at Harewood House, for instance, was supplied for £86, and other charges were on a similar scale.

We cordially congratulate Mr. Brackett on the care with which he has collected together all the available materials of Chippendale's life and on his success in producing an eminently readable and attractive volume. In view of the pleasure which he has given us, it may seem ungracious to cavil at a slight error in the first paragraph, where he seems to suggest that the Royal Society was founded in the eighteenth century. As a matter of fact, it came into existence in the seventeenth, the date of its foundation being usually given as 1660.

GENERAL NOTE.

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Candelilla Wax in the Ciudad Juarez District of Mexico.—The manufacture of candelilla wax in commercial quantities in the Ciudad Juarez district of Mexico is a comparatively new and important industry, according to the United States Vice-Consul there. The candelilla has grown wild and in profusion in northern Chihuahua for years, but all experiments to cultivate the plant have been unsuccessful. The possibility of manufacturing the product on a large scale has been precluded, on account of the remote region in which the candelilla is grown—more than 100 miles from the nearest shipping point. However, an American residing at La Jitas (Texas) is now operating a number of small wax factories just across the border and is finding a ready market for his product in the United States.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

Monday, December 15..Massage and Medical Gymnastics, Society of, at the Royal Society of Arts, John Street, Adelphi, W.C. 6.20 p.m. Dr. E. Cyriax, "Some Practical Hints in Mechano-Therapeutics."

Alpine Club, 23, Savile Row, W. 8.30 p.m.

British Architects, Royal Institute of, 9, Conduit Street, W. 8 p.m. Mr. A. J. Davis, "Shop Fronts and their Treatment."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 7 p.m. (Graduates' Section.) Mr. E. G. Davies, "Some Aspects of Works Management, with a view to cutting Costs of Production."

Geographical Society, 135, New Bond Street, W. 8.30 p.m. Major R. E. Cheesman, "The Deserts of Jafura and Jabrin."

University of London and Brown Institution, at the Royal College of Surgeons, Lincoln's Inn Fields, W.C. 4 p.m. Mr. F. W. Twort, "Modern Bacteriological Technique." (Lecture III.)

Electrical Engineers, Institution of (Mersey and North Wales Centre), at the University, Liverpool. 7 p.m. Mr. G. Rogers, "Automatic and Semi-Automatic Mercury-Vapour Rectifier Substations."

Victoria League, 22, Eccleston Square, S.W. 5 p.m. Mr. A. Yusuf Ali, "Lucknow."

Tuesday, December 16..Statistical Society, at the Royal Society of Arts, John Street, Adelphi, W.C. 5.15 p.m.

Botanic Society, Inner Circle, Regent's Park, N.W. 3 p.m. Prof. Bickerton, "Waves and Vibrations."

Civil Engineers, Institution of, Great George Street, Westminster, S.W. 6 p.m. Dr. T. E. Stanton, "Report on the Measurement of the Pressure of the Wind on Structures"

Marine Engineers, Institute of, 85, The Minories, E. 6.30 p.m. Mr. E. G. Warne, "The Development of Steam and of Oil Engine Machinery for Propulsion."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. L. B. Booth, "The Telephoto Lens." (Traill-Taylor Memorial Lecture.)

Illuminating Engineering Society, 15, Savoy Street, Strand, W.C. 7 p.m. Discussion on Shop Window Lighting.

Anthropological Society, 50, Great Russell Street, W.C. 8.15 p.m. Rev. H. W. Williams, "Some Customs, Beliefs and Traits of the Maori."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C. 4 p.m. Mr. J. S. Little, "Empires Old and New."

Auctioneers' and Estate Agents' Institute, 29, Lincoln's Inn Fields, W.C. 7.30 p.m. (Junior Members' Meeting.) Discussion on Presidential Address.

University of London and Brown Institution, at the Royal College of Surgeons, Lincoln's Inn Fields, W.C. 4 p.m. Mr. F. W. Twort, "Modern Bacteriological Technique" (Lecture IV.)

At King's College, Strand, W.C. 5.30 p.m. Baron A. F. Meyendorff, "Marxism Applied." 5.30 p.m. Mr. M. Kaye, "The Philosophy of the Absolute in English Thought." (Lecture II.)

Wednesday, December 17..Meteorological Society, 49, Cromwell Road, S.W. 5 p.m. (1) Mr. C. E. P. Brooks, "The Problem of warm Polar Climates." (2) Sir Napier Shaw, "Winds and Temperature in a Dry Atmosphere."

Microscopical Society, 20, Hanover Square, W. 7.30 p.m. Metallurgical Microscopy. (1) Dr. R. H. Greaves, "Super-saturated Solid Solutions." (2) Mr. H. Wrighton, "New Photomicrographic Apparatus for all Purposes." (3) Mr. J. E. Barnard, Lecture Demonstration on the Elementary Principles of Microscopical Illumination—(1) Transmitted Light.

Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

Civil Engineers, Institution of, Great George Street, Westminster, S.W. 6 p.m. (Students Meeting.) Mr. H. C. Reeves, "Mangahao Hydro-Electric Power Station."

United Service Institution, Whitehall, S.W. 3 p.m. Captain G. L. Harrison, "The French Army."

University of London and Brown Institution, at the Royal College of Surgeons, Lincoln's Inn Fields, W.C. 4 p.m. Mr. F. W. Twort, "Modern Bacteriological Technique." (Lecture V.)

Electrical Engineers, Institution of (North-Eastern Centre), Armstrong College, Newcastle-on-Tyne. 7.15 p.m. Prof. G. W. Howe, "Radio Telegraphy." (Faraday Lecture.)

Thursday, December 18..Chemical Society, Burlington House, Piccadilly. 8 p.m. (1) Messrs. W. H. Patterson and J. Duckett, "A Method of Determining the Presence or Absence of Complex Salts or Ions in Dilute Aqueous Solutions." (2) Mr. C. K. Ingold, "The Nature of the Alternating Effect in Carbon chains—Part I. The Directing Influence of the Nitroso-group in Aromatic-substitution." (3) Messrs. C. K. Ingold and S. D. Weaver, "The Additive Formation of four-membered Rings -Part VI. The addition of Azo-compounds to Ethylenes and some Transformations of the Dimethylene-1:2-diimine ring." (4) Messrs. F. R. Goss, C. K. Ingold and J. F. Thorpe, "The Chemistry of the Glutaconic Acids.—Part XVII. Three-carbon Tautomerism in the Cyclopropane Series—Part IV. (5) Mr. C. K. Ingold, "The Condition underlying the Formation of Unsaturated and Cyclic Compounds from Halogenated Open-chain Derivatives—Part IV. Products derived from Halogenated α-methyl glutaric Acids."

Linnean Society, Burlington House, Piccadilly, W. 5 p.m. (1) Major T. F. Chipp. "The Fruiting of the Groundnut." (2) Mr. E. J. Collins "The Physiological Aspect of Blight Infection(*Phytophthora infestans*) of Potatoes." (3) Mr. W. P. Westell, "Remarkable Form of *Pastinaca sativa*, new to Britain." (4) Major R. B. Seymour Sewell, "A Study of the Andaman Sea Basin."

Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p.m.

Aeronautical Society, 7, Albemarle Street, W. 5.30 p.m. Mr. A. R. Watson Watt, "Recent Studies on Radiotelegraphic Atmospherics."

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

London County Council, at the Geffrye Museum, Kingsland Road, E. 7.30 p.m. Mr. E. Hawking, "Old Furniture and its Construction."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. Mr. D. Murray, "Speeding up the Telegraphs: a Forecast of the New Telegraphy."

Mechanical Engineers, Institution of (North Western Section), at the Engineers' Club, Manchester. 7 p.m. (1) Prof. F. C. Lea, "The Effect of Low and High Temperatures on Materials." (2) Mr. J. M. Lessells, "The Elastic Limit in Tension and its Influence on the Breakdown by Fatigue."

Friday, December 19..Automobile Engineers, Institution of, Watergate House, Adelphi, W.C. 7.30 p.m. (Graduates' Meeting.) Mr. H. E. Merritt, "Tooth Gearing."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Meeting of the Pictorial Group.

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 6 p.m. Report of the Wire Ropes Research Committee.

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FRIDAY, DECEMBER 19, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

CHAIRMAN'S INAUGURAL ADDRESS.

The Inaugural Address of the Chairman of the Council, which had to be postponed from November 5th owing to his unavoidable absence abroad, was delivered on Thursday, December 11th, by SENATORE GUGLIELMO MARCONI, G.C.V.O., LL.D., the subject being " Radio Communications."

The Swiney Prize and the medals awarded for papers read last session were presented.

On the motion of MR. ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council, seconded by SIR ARCHIBALD DENNY, Bt., LL.D., Member ot the Council, a vote of thanks was passed to Senatore Marconi for his address.

The address will be published in the *Journal* of December 26th.

CANTOR LECTURE.

On MONDAY, DECEMBER 8th, DR. LOUIS C. MARTIN, A.R.C.S., D.Sc., Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and Technology, South Kensington, delivered the third and final lecture of his course on " Modern Colour Problems."

On the motion of the CHAIRMAN, DR. F. W. EDRIDGE-GREEN, C.B.E., F.R.C.S., a vote of thanks was accorded to DR. MARTIN for his interesting course.

The lectures will be published in the *Journal* during the Christmas recess.

FIFTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 10th, 1924. MR. J. IVE, Vice-President of the Anglo-Colombian Chamber of Commerce, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Bates, Walter, Richmond, Indiana, U.S.A.
Bond, Benjamin Davis, M.A., M.D., Kohala, Hawaii.
Burne-Jones, David, London.
Canning, Arthur Richard, London.
Dunne, Daniel Patrick, Clifton Junction, Manchester.
McMichael, Leslie, London.
Tejpal, N. L., Ludhiana, Punjab, India.

The following candidates were duly elected Fellows of the Society:—

Caftoor, N. D. H. Abdul, Colombo, Ceylon.
Hodgson, Edgar Stanley, Whitefield, Lancs.
Hopkins, Miss M. H., London.
Kielberg, Ferdinand K., Liverpool.
Sporborg, H. N., Rugby.
Wolton, John David, Mem.Am.Soc.M.E., London.

A paper on "Colombia as a Field for Development" was read by MR. NORMAN THOMSON. Amongst those who took part in the discussion were His Excellency the Colombian Minister (Señor Dr. Don Luis Cuervo Marquez) and Dr. Gabriel Posada Villa, member of the Colombian Government, who is at present on a visit to this country.

The paper and discussion will be published in a subsequent number of the *Journal.*

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "Colloid Chemistry" by Eric K. Rideal, M.B.E., M.A., Ph.D., D.Sc., F.I.C., have been reprinted from the *Journal*, and the pamphlet (price 1*s.* 6*d.*) can be obtained from the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures which have been published separately and are still on sale can also be obtained on application.

PROCEEDINGS OF THE SOCIETY.

FOURTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 3RD.

SIR ROBERT ABBOTT HADFIELD, Bt., D.Sc., F.R.S., in the Chair.

THE CHAIRMAN said he had had the advantage of reading an advance copy of the paper by Professor Carus-Wilson entitled "The Teaching of Science in Secondary Schools," and he was quite confident that it would prove of great interest to the meeting. Mr. Carus-Wilson was a Cambridge man, and had unrivalled experience at the Royal Indian College, Coopers Hill. He was also Macdonald Professor of Electrical Engineering at McGill University, Montreal, and his knowledge of education was very wide.

The paper read was :—

THE TEACHING OF SCIENCE IN SECONDARY SCHOOLS.

BY PROFESSOR C. A. CARUS-WILSON, M.A., F.R.A.S.

The Teaching of Science in Secondary Schools was the subject of a very complete investigation by a Committee, presided over by Sir J. J. Thomson, whose report was issued in 1918. The Terms of Reference were "To enquire into the position occupied by Natural Science in the Educational System of Great Britain, especially in Secondary Schools and Universities, and to advise what measures are needed to promote its study, regard being had to the requirements of a liberal education, to the advancement of Pure Science, and to the interests of the trades, industries, and professions which particularly depend upon Applied Science." The Committee say :—"We consider that the best preparation for any occupation or profession is a general education up to the stage reached by the average boy at the age of 16, followed, where possible, by a more specialised course on a limited range of subjects. This general education should provide normally for the study of English, including History and Geography, Languages other than English, Mathematics and Natural Science : each of these subjects should be regarded as an integral part of the education of both boys and girls. . . The point is sometimes made that the study of science can be more effectively pursued if it is taken up in the later stages of school life. . . But we are concerned with the education of the citizen, with the diffusion of scientific conceptions and the habit of mind their study induces among the general mass of the educated population. . . We recommend that systematic instruction in science should be part of the general course of education up to 16 in every Secondary School."

The report advises that the science taught should consist of three parts :— A Preliminary Course, a General Course and an Advanced Course, the first two being taken by all students and the last only by those who intend to specialise in science. No serious question is raised with regard to the work to be done in the Preliminary Course : it would deal with the elements of Botany, Physiography and Astronomy, presented from a purely descriptive standpoint. The majority of the students taking the Advanced Course would have some examination in view, and the work done in that course would, therefore, be determined largely by the examination syllabus, and the subjects taught could not be varied to any considerable extent.

The real difficulty connected with the teaching of science at a Secondary School is encountered in the General Course, for this has not only to serve as a foundation for the work done later by those who go on to the Advanced Course, but also to give to that much larger body of students, who are not going on to the Advanced Course, a broad view of science as a whole that will be helpful to them in any calling they may take up in after life. The report says that the General Course "should train the mind of the student to reason about things which he has observed for himself and develop his powers of weighing and interpreting evidence: it should also make him acquainted with the broad outlines of great scientific principles, with the way in which these principles are exemplified in familiar phenomena and with their application to the service of man. . . The course should give special attention to those natural phenomena which are matters of everyday experience, . . . the science taught in it should be kept as closely connected with human interests as possible."

The primary requirement is that the General Course should deal with science as a whole. At the present time, however, this is not done. In the majority of Secondary Schools, science is broken up into sections—Mechanics, Heat, Chemistry—each of which is taught as a separate subject. The reason for this is that science is taught in this way for examination purposes during the Advanced Course, and it has been assumed that the work in the General Course must be on similar lines. So long as the Universities continue to impose upon the Schools the present system of examinations, this breaking up science into sections will be unavoidable in the Advanced Course. But in order that this method may be applied to the General Course, the subject has to be watered down to a lower level, a process fatal to the best interests of the larger number of students, as has been well pointed out in a recent leading article in *Nature*:—

"The School Science Teacher . . . . soon realises that successes in examinations are held in high esteem, and that success is most surely attained by teaching what has been aptly described as 'college science and water.' A small percentage of pupils from the schools proceeds to the Universities . . . . but what about the rest, whose instruction in science ends with their schooling? The unpleasant truth is that the future needs of many are sacrificed to the immediate needs of the few: and school science tends less and less to be taught in effective relation with life as it is and with things as they are in the great everyday world, and more and more as it is dealt with by professionals in seminaries."

The assumption that the work done in the General Course must be a watered edition of that in the Advanced Course has its origin in the teacher's own training. The report says:—"Examinations cannot be blamed for all the faults which have been pointed out to us: it seems certain that a great part of the difficulty arises from the fact that the teachers . . . . tend to go on teaching as they were taught themselves, and thus the work becomes stereotyped." This view has been ably stated by Professor Arthur Smithells, F.R.S. In the Presidential Address delivered by him before the Science Masters' Association at their annual meeting last January, he said:—

"Universities are now centres of professional training. It is this fact that determines the content and, in a great degree, the method of their teaching. It leads to a series of convenient formalities of procedure of a highly artificial kind. In science it leads at once to a segregation of subjects and an unnatural delimitation of frontiers, leaving us with a set of separated members of the whole corpus of natural knowledge. We seem almost compelled to drag our subject from its association with the life and things of every day: to make an abstract, or, as we say, a " pure " science of it. We devise a sort of logic of condensed presentation, make categories, fix arbitrary limits of information, and so end with a kind of canonical version of physics, botany, or whatever the science may be, an orthodoxy whose grip is aided by the iron hand of the examiner, and by the written word of syllabuses and text books. Thus we methodise our teaching with little heed of the fact that we are almost inverting the natural way of learning. For we really know well enough that in the natural way of learning about natural phenomena, we have our topic intertwined with more than one of our formal branches of science at once, and not only so, they stand in direct linkage with our life and history and with all the rest of knowledge. . . . It is, however, not the University teacher or his functions that I wish to discuss. But what I do wish to stress, with all the emphasis I can give, is the unnatural form which natural knowledge acquires under conventional University conditions, because I think that the greatest difficulties of the science teacher in school have had and still have therein their real source."

Assuming that the teacher is willing to break away from those " conventional University conditions " which have hitherto dictated his method of teaching, we still have to find a satisfactory alternative, by which Science may be presented to the student as a comprehensive whole. The author hopes to be able to show that a solution to this problem is to be found by taking one central theme round which all the various branches of science may be grouped, that central theme being " The Properties and Uses of Materials."

The phenomena with which science has to do result from the association of matter with force and energy, and depend mainly upon the properties of the matter concerned. Suppose, for example, that an experiment is being made in which a wooden rod is supported at the centre and loaded by a weight hung on a cord attached to both ends. The principles of mechanics enable us to calculate the tension on the cord and the forces acting on the rod. But these calculations take no account of the effect of the force on the material of which the rod is made: they assume that the rod is perfectly rigid, and the deflection of the rod, which is the really important aspect of the phenomenon, is not considered. The true character of the phenomenon can only be rightly understood by taking account of the elasticity of the rod; but our academic method of teaching mechanics finds no place for elasticity, so that the practical side of the problem is ignored. If, however, we had taken properties of materials as our central theme, we should have used this experiment to investigate the nature of elasticity, utilising to the full all the information that mechanics could give as to the way in which the forces acted. Mechanics would thus be brought in as a means to an end, namely, to learn something about elasticity and its influence on the behaviour of materials in practice. The experiment would be repeated with different kinds of wood, in order to compare their resistance to bending, and this would lead on to a discussion as to the practical uses of the various woods, and the elasticity required in each case, the subject thus being kept continually in touch with the practical side of things.

These experiments on elasticity suggest experiments on other properties, such as the ultimate strength of wood, and it soon appears that some woods, such as ash, have a peculiar combination of strength and elasticity by which they can resist shock, namely, toughness, the measure of which is the amount of the energy they can absorb before breaking. The student is thus introduced to the idea of the association of matter with energy, an idea of great theoretical and practical importance. This property of toughness, in common with elasticity, finds no place in our system of science teaching. Thus, when a boy is being taught the principle of the lever, he may be shown how to work out, to the fraction of a pound, the force on the blade of an oar. He will probably think that he knows all about it, and may leave school without a suspicion that unless an oar is made of suitable wood, possessing this property of toughness, all his calculations will only lead to disaster. Thus properties which profoundly influence the behaviour of matter in practice, and affect the use of materials in every kind of human activity, domestic, commercial and industrial, find no place for consideration in the ordinary school science course, because they do not happen to be included in any one of the recognised branches of science usually dealt with.

By taking the properties and uses of materials as the central theme of the science course, the practical side of every problem is fully considered, and mechanics takes its proper place, not as a subject to be studied by itself, but as a help in studying the central theme.

In the same way heat will no longer be dealt with as an isolated subject, but will be regarded as something by which changes are brought about in density, ductility and other properties of materials. Familiar experiments, like that of the extension of a metal bar, will acquire an altogether fresh significance as they are used to reveal new facts about the nature of matter itself, for example, that the expansion of a metal depends upon its elasticity, and that the most elastic metals expand least. These are the really significant facts that should be brought out by a study of heat in a general science course: they are of greater importance than such exercises as the construction of thermometers, which at present occupy so much of our time.

The materials to be considered in this course will include solids, liquids and gases, and frequent reference will be made to the composition of these substances. This will call for a knowledge of chemistry and will determine its place in the general science course. Opportunity will thus be afforded for the introduction of mechanics, heat and chemistry, each of which will be used, as occasion requires, to throw light upon the various questions that come up for discussion.

There are two ways in which a course of this kind may be conducted. We may take the properties of matter and consider them one by one, with illustrations from various materials, or we may take different substances and examine the properties possessed by each. The former would be the method adopted if the subject were being taught at a University: it was the method used by Professor Tait, who made properties of matter the foundation of his course of natural philosophy at Edinburgh University. At a Secondary School, however, it is better to take the materials one by one and to consider their properties, as this brings the work into more direct touch with the facts of the student's own observation.

The following is a brief outline of a general science course arranged on these principles and based upon the author's own experience at a large Secondary School. The materials selected for consideration are chosen from amongst those substances most commonly met with in daily life, and are divided into three sections: (A) dealing with solids, (B) with water as the typical liquid, and (C) with air and coal gas as typical gases. These three sections are carried on simultaneously in parallel divisions, so that a class having three periods a week may, for example, be studying wood in one period, water in another and air in a third. Specimens of each material are passed round for identification and inspection, and discussion is invited on any facts about the substance that may be supplied by previous observation. Experiments are then made to demonstrate the various properties, and illustrations given to show how these are utilised in practice.

SECTION A. SOLIDS.—Wood is placed first in the list of solids on account of its general interest and importance, and because it forms a link with the Botany and Nature Study already done in the Preliminary Course. Specimens of various kinds of wood are examined—oak, ash, elm, beech, walnut, pine, teak and mahogany—and experiments are made to exhibit their properties—density, elasticity, toughness and strength. Sections with and across the grain are shown, and the influence of the natural growth of the tree on its properties is discussed. Attention is then directed to the reasons why certain woods are used for special purposes, and to the properties that are required in wood that is to be used for making various things, such as hockey sticks, cricket bats, racquets, fishing rods, bows, planks, ladders, scaffolding, piles, joists, gates, boats, masts, oars, wheels, spokes, shafts, railway carriages, sleepers, wood paving, pulley blocks, and tool handles.

Other organic substances are then examined:—Rubber, cork, ivory, amber, leather, catgut and experiments made to illustrate their properties and uses, for example, the resilience of rubber, and its use in the rubber tyre, and the golf ball: the elasticity of ivory and its effect on the play of a billiard ball: the electrical properties of amber: the toughness of leather and its value for making belting: the tenacity of catgut and its use for violin strings where the note depends upon the tension and upon the density of the string.

The next group of substances considered comprises certain inorganic materials, such as quartz, corundum, asbestos and mica. Amongst the special facts observed are :—The transparency and crystalline structure of quartz: the hardness of corundum and its use in emery grinding: the non-conductivity of asbestos and its use in fireproof sheeting: the cleavage of mica and its use as a non-conductor.

Some preliminary ideas as to the nature of heat and its effect on solids are now introduced by experiments with paraffin wax. Observations are made, at ordinary temperatures, of its density, hardness and translucency, all of which are shown to be affected by the application of heat, the translucent solid becoming a transparent liquid with a remarkable decrease of density. The results of these experiments are compared with those obtained in the parallel course dealing with the properties of water, showing how its density decreases when changing into ice.

The properties of glass, its composition, density, elasticity, transparency, brittleness, and smoothness now open up a wide field for discussion and experiment. Its hardness is compared with that of corundum and diamond, and the process of glass-cutting explained. Under the influence of heat it loses it brittleness and becomes ductile. . Its manufacture is described. Other artificial substances are then taken up, such as vulcanite, celluloid and crystalate, the elastic properties of which are examined, the action of a crystalate billiard ball being compared with that of one made of ivory.

Great importance is attached to the study of the metals, those selected for consideration being lead, copper, iron, aluminium, nickel, zinc, tin, silver, gold, mercury and platinum. Specimens of these are procured, where possible, in the form of cylinders, rods, balls, wires and strips. The cylinders are used for finding relative density, the rods for finding elasticity, heat conductivity and expansion, the balls for specific heat and hardness—by the method of rebound, the wires for finding the tenacity, ductility, electrical conductivity and melting point, and the strips for comparing toughness, hardness —by scratch method, lustre and colour, and for general inspection purposes. Malleability is studied by examining and comparing specimens of beaten leaf of gold, silver, aluminium, copper and tin. For comparing the melting points a rough scale of temperatures is arranged based upon the known temperatures of the luminous and non-luminous parts of the Bunsen flame, and of first visible red, dull red, cherry red, orange red and white heat: specimens of wire of each metal are tested in the flame and the position of the melting point approximately determined. The most notable properties of each metal are specially dealt with, such as the tenacity and magnetism of iron, the density and ductility of lead, the toughness and conductivity of copper, the lightness of aluminium, the conductivity and lustre of silver, the malleability of gold and mobility of mercury. Finally, to show how the properties of metals may be altered by mixture, the various alloys are considered, the copper-zinc, copper-tin and lead-tin alloys, the alloys of gold, silver and copper used in coinage, and, most important of all, the iron-carbon alloys.

SECTION B. LIQUIDS.—Water is selected as the typical liquid on account of its universal importance and general interest, and the study of its properties and uses is such a large subject that it is extended throughout the whole of the time devoted to the section, already described, dealing with solids. Experiments are first made on the chemical composition of water, the difference between hard and soft water, and the composition of sea water. The weight of water is then determined, and the density and buoyancy of fresh and sea water compared. This leads to experiments dealing with the floating of bodies lighter than water. The resistance that water offers to change of volume is illustrated by the hydraulic press. After dealing with the storage of water, and the pressure in tanks and reservoirs, water in motion is considered, first in open conduits and then in closed pipes. This leads to the study of the pressure in pipes, its measurement by the Bourdon Gauge and other methods, the effect of friction, and how pressure is affected by flow. By way of illustration details are given of the supply of water to Liverpool, with description of the pipe line from the Vyrnwy Reservoir. The effect of heat on the properties of water are now taken up, and experiments made to show the change of density with temperature, the conditions under which ice is formed and the properties of ice, its density, smoothness, softness and transparency. Experiments are then made on the evaporation of water, and the formation of steam with consequent changes in volume and pressure.

SECTION C. GASES.—The substances selected for consideration in this section are air and coal gas. The study of air and its properties is begun at the commencement of the general course. The study of coal gas is begun later, when some preliminary ideas about heat will have been taught in other parts of the course. Experiments are made on the chemical composition of air, its weight and elasticity; on the pressure of air, the effect of heat on air, the transmission of sound waves through air, and the function of air in the process of combustion. The properties of air are illustrated by a description of various apparatus, such as the U tube pressure gauge, the mercury and the aneroid barometer, the air pump, the hot air engine, the air brake, the pneumatic despatch tube, the pneumatic tyre, the diving bell and the Kelvin sounder. The study of coal gas begins with its chemical composition and process of manufacture. The storage of gas, its pressure and transmission through pipes is considered, and the construction and use of the meter explained. The chemistry of the combustion of gas is then taken up, and experiments made to ascertain the amount of heat in a cubic foot, the results being compared with the heat obtained by the combustion of other substances, such as wood and coal.

A study of the properties and uses of materials, such as that outlined above, fulfils the first requirement of a General Science Course, that it should give to every student an acquaintance with scientific facts and principles which will be of value to him in after life. It will be of equal value to the student who intends to go on to the Advanced Science Course, for the facts with which he will then have to deal cannot be understood without a knowledge of the properties of matter. The phenomena of sound, for example, depend upon the vibrations of certain substances, and the elasticity of the substance is a vital factor in the theory of those vibrations : a knowledge of elasticity is, therefore, essential, and this should be acquired before the student enters the Advanced Course. To take another illustration. A knowledge of the properties of water is of value, not only from a practical point of view, but because deductions may be drawn from the analogy of water which will be of great assistance to the student when faced with difficult problems in other branches of science. The flow of an electric current in a wire, difference of potential, the action of condensers, and all questions relating to electrical work and energy, can be most easily explained by making use of the analogy of water pressure, flow, level, head, capacity and quantity. Thus the method of measuring water quantity in a Venturi meter by loss of pressure affords a most helpful analogy to the measuring of electrical current in an ammeter by fall of potential.

One result of our system of presenting the student with a "canonical version" of science is that he is led to suppose that it contains the whole truth about the matter, and is thus discouraged from making original investigation. But if the subject is approached from the new standpoint, he finds it is not by any means so cut and dried as he thought ; that there are many problems connected with it still awaiting solution ; and his imagination is fired with the idea that it may be for him to solve them. Thus, he is taught that every metal has a definite melting point, and he concludes that this is a fact about which there is nothing further to be said. If, however, the subject is regarded from the point of view of the properties of materials, the questions at once occur to him : Is the melting point a property of the metal ? If not, what property does it depend upon, and why does one metal melt at a higher temperature than another ? He then finds that if the metals are arranged in the order of their melting points, that order will be identical with the order of their volume elasticities, and that a metal with a high melting point is a metal with a high elasticity. He is now inspired with the idea of finding out why the melting point depends on the elasticity, and the result is that his mental outlook on the whole subject is profoundly altered. The heuristic spirit has been aroused : this is the real test of successful teaching : for this alone will encourage in our young people that enthusiasm for investigation which is such an essential factor in their education, and enable them to retain the Vision which is the natural heritage of every child.

In conclusion, we have to consider by what means it is possible to bring about any change in the teaching of science. The position is somewhat peculiar. The Education Authorities will not dictate how science should be taught in our schools: they prefer to leave the matter in the hands of those who have to do the teaching. Any reform, therefore, must originate with the teachers themselves. Their attitude on the question has been indicated by the President of the Science Masters' Association, who made it clear, in the address already quoted, that the members of that association are fully alive to the importance of considering new methods. The proposals outlined in this paper have been already brought before them, and before the Association of Women Science Teachers, and have been favourably received. The carrying out of these proposals, however, would mean great additional effort on the part of the teachers, and it is in the hope that public opinion will encourage and appreciate this effort that the author brings the subject forward on this occasion.

DISCUSSION.

THE CHAIRMAN in opening the discussion, said it would be admitted by all who had heard the paper that Professor Carus-Wilson had made some very valuable suggestions, well worthy of consideration by educational authorities and those taking interest in the subject, which were of the highest importance to the Empire. Science in this country had often been described as the Cinderella of education. Whilst that was all too true, there was no doubt that happily of late our views had been modified and widened. Whilst some might still question the value of a specialised training, all would agree that a proper foundation, such as Professor Carus-Wilson had spoken of, was necessary to every one. His own feeling was rather in the direction of general training after a certain age than specialising too much on the line of work which the individual intended to take when launching out into the world. As time went on, more and still more highly specialised education was found to be necessary; hence the subject of the paper, which so ably described the best method of teaching science in secondary schools. Never having himself tried to train any one, it seemed rather anomalous that he should be in the Chair that evening, but in any case no one had tried harder than himself, so far as he had had opportunity or influence, to arouse general interest in the teaching of science amongst all classes with whom he had come into contact. His industrial life had commenced when he was about 17 years of age, and he had not had much time to acquire further knowledge by the ordinary methods of teaching. Fortunately, however, his father had wisely given him opportunities of becoming well grounded in the study of science, chiefly physics and chemistry. His ambition to know more about those branches of science had been fired by what then appeared to him, and still appeared, that very wonderful book, Pepper's "Playbook of Science," which had had a remarkable effect on his mind. He was glad to learn that one of those present that evening, Professor Armstrong, whose knowledge on educational matters was very wide, had similar thoughts regarding this book. Moreover, Professor Armstrong had studied under Professor Pepper. Another very important book, also by an Englishman, and a Fellow of the Royal Society, the late Dr. G. Gore, entitled "The Art of Scientific Discovery," had also appealed to him. In it he believed Professor Carus-Wilson would find much support for his point of view, both directly and indirectly. That book, in his opinion, ought to be republished and distributed broadcast by the Government itself. He had once had the pleasure of lending a copy to the late Sir William Osler—quite a master on educational science. Time went on, and he wanted the book back. On applying to Sir William for it he had received a most peremptory letter to say he really could not part with the book, or, at any rate, could not he (the speaker) find another copy, which he did.

In reading through the paper he had placed crosses against the points on which he agreed with the author, and those crosses were numerous. There were very few points on which he did not quite agree. It was rather a coincidence to him to find that the paper opened with a reference to the Committee presided over by Sir J. J. Thomson to inquire into the position occupied by Natural Science in the educational system of Great Britain. A questionnaire had been sent to him by that Committee, and he had submitted several lengthy statements in reply, which he was told afterwards had been found of some use. The head of one of the largest research laboratories in America had recently said:—"We are patenting inventions at the rate of nearly 50,000 per annum, but very few Americans are advancing the sciences at all. This tends to show how much it is needed that steps should be taken to organise the teaching of pure and applied science, whether as regards physics, chemistry, electrical engineering or metallurgy, or any other branch." With the aims and objects set forth by the author that evening he had great sympathy. He had carefully thought over the suggested methods, and he agreed with the author that the reconsideration of the methods of science training demanded special attention. Whilst science did not do everything, still the time was fast approaching when those termed the masses of the country should receive some scientific training. It would be admitted by all that present methods were still somewhat cumbersome, and too slow. The subject of the teaching of science in secondary schools had received considerable attention from the Society, the following papers having been read, viz.: "School Work in Relation to Business," by Sir Joshua Fitch; and "Literature and Science in Education," by Mr. A. C. Benson. We had in this country tremendous competition to face in the near future; we were in financial difficulties, yet there was one item of expenditure which ought not to be touched—and he was in hearty sympathy with the Labour Party in that respect—namely, the money spent on education.

PROFESSOR H. E. ARMSTRONG, F.R.S., referred to a picture in the current issue of *Punch* of a mother giving, he supposed, a Scripture lesson to her child, with the subscript:

> "'What do you remember of Adam and Eve'?
> 'They were puffickly happy until the servant came.'"

Men had been moderately happy—until Science came as the Steam-Norn. Industrialism then set in and we at once began to over-populate our country, to live mainly by eating coal and upon other peoples, teaching others the while to copy us. Science too had given man such control over nature, that he had been able to defy her in large part, so that she no longer kept him in order as she did in the good old days. Science was fast carrying us to perdition, he held, because the peoples were using up the raw materials of the world at an entirely unjustifiable rate, in thoughtless competition and the struggle to maintain if not increase their numbers. If we were to make any progress at all, to maintain ourselves even, the public generally must learn to understand the struggle in which we were engaged and the character of the weapon we were using so largely against ourselves, scarcely at all in our service, outside medicine. The paper under discussion would not have been necessary if that lesson had been learnt, if we had made the spirit of science of public avail; it neither entered into politics nor into our system of government; only a few days ago, the Prime Minister had chosen to proclaim that he was not a "theorist." It was a confession of failure to bring forward, so late in the day, an academic scheme such as they had heard described, though the scheme itself was admirable.

Though not quite a greenhorn—he began to teach in 1870 and to talk and write publicly in 1884-5—he was now a "dry"-horn, and had nothing new to say. In an address which he had given recently in the University of Birmingham (*Chemistry and Industry*, October 31st and November 7th, 1924), he was able to point out that, in 1880, when Huxley delivered the address at the opening of the Mason College, the forerunner of the University and many of our technical schools, on which occasion he (the speaker) had been present, Huxley's theme was *Science and Culture*, not Science and Industry. His contention was that science ought thereafter to play a large part in *general education*. Professor Armstrong said he had asked Birmingham to consider what had been done towards justifying Huxley. He had ventured to point out that nothing had been done by the University to make science of avail to the general public, as a *cultural subject*. "Science" was taught merely as a qualification for a professional career; Birmingham and other modern Universities had failed to teach it from any general point of view, to all and sundry. Their students were all in search of professional qualifications. The attempt made to teach what we were pleased to call science was a failure in practically all schools, because the method of science was not taught. The public stood in need of the spirit, not of the material side, of science. The scientific men of to-day were but an excrescence upon society, freaks for the most part; they did not represent, in any way, the character or general average of intelligence. The problem was a much greater one than that of the mere introduction of a new course. University teachers were but professional teachers and the vicious circle in which they were held must somehow be broken—the vicious teacher displaced. Until the Universities were rationalised, little could be done in the schools; there was little chance of success, as the teachers came from the universities and were controlled by their examinations.

He (Professor Armstrong) long ago came to the conclusion that the attempt must be made to teach the method and simple elements of science *in all its branches*, not any specific section, in a general course. He had ventilated the subject and there was considerable discussion; ultimately, a Committee was appointed by the University of London to go into the matter and, after much deliberation, the Committee drew up a general syllabus. He recollected meeting Professor Sylvanus Thompson, and asking him what the scheme was. The reply came: "Armstrong and water." An attempt was made to put the scheme into operation, and one of the main operators was Professor Ramsay, than whom a worse man could not have been chosen, as he had no sympathy whatever with the biological side. After a few years, the attempt lapsed. Latterly, the Science Masters' Association had been talking about "Science for All," but it was beyond them; there was not a man available to cope with such a task and it could only be undertaken when a general course was given at the Universities which would qualify teachers to give such teaching. Oxford and Cambridge were but technical schools for Honours men; a large number went there who were not Honours students, and these only received social training. No attempt was made to cater for such men in "science"—to put the "Spirit of Science" into them; not even a simple broad course of lectures on Evolution or any subject of that kind was given. The universities must be led to recognise that they had a public as well as a professional duty; also the "curse of examinations" must be got rid of. Under the present examination system, there was neither freedom of teaching nor freedom of learning; the system was a wicked one. The profession of teaching ought to be regarded as the highest of all professions, but it was not so in England. In Germany, in the old days, every one took off his hat to the teacher; his students had always made a point of keeping their hats on when they met him. The teacher should be put on a level with other professional men. The patients of the medical man and of the dentist, the clients of the lawyer, were not examined. The lawyer and the medical man were given their "qualification" and then they were supposed to be honest men and to do their work up to the level of their proficiency. The teaching profession received no consideration whatever from the public; it was constantly examined and worried, directly through inspectors and indirectly through the children. Then, behind the system, there was the desire of Headmasters for advertisement. Outside examinations must be got rid of, in order to give freedom to the teacher and freedom to the children, to break down a system ever becoming more Procrustean and mind-limiting as knowledge grew. Particularly was this the case in the Universities. The college entrance examinations set at the universities were of the "tallest" possible kind, hopelessly artificial and academic; these made rational teaching impossible in schools. All the subjects in school should be interlocked, he thought. He looked forward to a time when the "geography" master would be the master of Method. He would call the tune, and subjects would be taken in the most haphazard way, at his direction, to meet the opportunities of the moment and the immediate requirements of each particular class of pupil. If we thought of "Geography" in terms of our own language, not of Greek, we might attach a rational meaning to the word, such as was conveyed in the simple German terms—*Erd-Kunde* and *Erd-Lehre*, Earth-lore. What men wanted was as much earth-lore as possible; as much understanding as possible of the world in which they live. No understanding of the world in which we live was acquired under the present school system; the vain attempt was made to teach the high-falutin tricks of the researchers in science; that was mainly laboratory slang not earth-lore.

MR. WALTER C. HANCOCK said that as a nation we were probably one of the most unscientific at the present time, although it was not too much to say that the first great advances in science had been achieved by Englishmen. As one who had been engaged for some years in consulting practice in London, he found that one of the difficulties the consultant was up against was that the average person attached to industrial works was most profoundly ignorant of the simplest fundamental principles of science. A great part of the reports which consultants had to make was taken up with explaining a few simple, obvious facts which ought to be common knowledge to any one who had had anything approaching to a liberal education. So far as teaching was concerned he could speak with comparatively little experience. He thought the great object of the teacher, as Mr. Carus-Wilson had said, ought to be to inspire the heuristic spirit in his pupils. He had to deal with a good many students of B.Sc. standard or its equivalent, and when they came to him with difficulties he always encouraged them to devise some experiment which would enable them to find the solution. Although it had always seemed to him impossible to expect the average student in an ordinary course to discover independently for himself the fundamental principles of science, since the fundamental laws known to-day had been evolved by the patient work of some of the ablest intellects the world had produced, yet it should be possible to indicate to a student the way in which he could attack a problem experimentally. He had noticed that Professor Carus-Wilson in his summary had made practically no reference whatever to the biological sciences, but that was probably provided for in the paper. He agreed that examinations were a great hindrance to freedom, and that we ought to get back to the days of 1880 to which Professor Armstrong had referred, and remember that science could be of cultural influence in education.

Mr. J. C. Bentley said that perhaps his only right to interpolate a remark in the discussion was that he happened to be one of those fortunate young men who were trained in their early days by Professor Armstrong, and that there was one statement which the Professor had made that evening which was totally and absolutely inaccurate. Professor Armstrong said that no one had ever taken off his hat to him as a teacher. He wished to assure him that on many, many occasions when he had been considering what particular line he should take in dealing with a particular educational problem he had indeed often mentally taken off his hat to his old teacher. The problem of science teaching in the schools was a very difficult one, for two reasons. It was difficult on account of the two conflicting ideals of science education. There was the ideal of establishing in the pupil's mind the heuristic spirit, which took a good deal of time and a lot of elaborate experiments. A great headmaster had once said (and he cordially agreed with him): " I do not care whether my boys when they leave have learnt anything ; what I do want to know is whether they have learnt how to find out things." There was also the other point of view raised by a previous speaker, that he found a great many men who left school in ignorance of a great many scientific facts. If one had to give the boys a great amount of scientific information it meant that one had to take away from the hours spent on experimental research ; and therefore it was necessary to have clearly in mind the object to be aimed at whether that object was to give the boys a wide range of scientific knowledge, or to concentrate on the ideal of giving them the heuristic spirit. His own feeling was strongly that one could not do better for any boy, whatever line of life he might take up, than by giving him the heuristic spirit. In that connexion there was another great difficulty—that one must have, as a teacher, a man, who had been trained, anyhow to some extent, in scientific research. In the schools at the present time one might get an honours man who had taken up mathematics, applied and pure, with physics (say) as an extra subject, and when he came to the school he had probably done the minimum amount of experimental work, and was appointed science master of the school. He knew the little physics he had had to acquire for his degree examination ; he had probably done no chemistry whatever except what he had had to do for his intermediate examination, and yet he was put on to take boys in scientific training. He wished to submit that until the teachers in the schools were men who had been trained in research methods it was useless to expect them to be capable of imparting the research spirit to their pupils.

Professor Carus-Wilson said he would like to touch upon a point raised by Professor Armstrong with regard to examinations—namely, that until we got rid of the examination system imposed upon the schools by the universities we should never really make any progress. He thought that was rather a pessimistic view. His contention was that if a boy had been taught on the lines suggested, he could after that spend his final two years at school on his matriculation work, and do well in his science examination. The school course might be divided into three sections—preliminary, general, and advanced; the advanced work during the last two years being specially for the boys who were going to take examinations, and the preliminary and general for everybody. The preliminary work would include the biological work to which allusion had been made by one of the speakers, and the general course would be occupied with the subject he had attempted to set out in his paper. He contended that any secondary school was quite free to do what it liked with the general course stretching over three years of the school course. The boys who were going to take the science examination would then go on to the advanced course, and they could easily get through that in two years if they had a thorough grounding beforehand. Secondary schools were not so bound by examinations as was generally thought. At present the work imposed on all the boys in the general course was on examination lines. In his view that was entirely unnecessary. It was open to any secondary school, if it chose, to set before them the question of how best to spend the middle three years of the school science course. That question could be answered in the way he had indicated without imperilling the chances of success of the clever boys at the universities. Secondary school teachers got it into their heads that the university examination system must control the whole of the science course; but he contended that was not so. The scheme he had described would enable teachers to give the mass of the boys what was wanted, and at the same time prepare the advanced boys for going on to take their strictly examination work in their last two years. With regard to Mr. Bentley's remarks about the heuristic method, there was nothing that gave a teacher so great pleasure as the feeling that he was inspiring in his pupils the idea of "finding out"; but he did not think it was necessary, in order to do that, to go through a very elaborate process of investigation. To his mind the important point was the spirit that one inspired. The suggestion that he had made, for instance, with regard to elasticity and the melting-point, did not involve a long investigation, but was the result of so dealing with the properties of matter, as to give a new outlook on the great question of heat. During the war he had an experience which gave him great pleasure. He was teaching a class of boys on one occasion, and a little chap had come to him with an envelope full of something. He asked what the packet contained. The boy replied that it was cosmic dust. "Cosmic dust?" he had asked. "Where did you get that from?" The boy explained that the previous Sunday he had been on the top of Barnet church tower, and had scraped the dust from the roof. He asked the boy how he knew it was cosmic dust? The boy replied, because it was magnetic. He had not told them anything about cosmic dust, but this boy's mind had been working on the lines suggested by the lessons. That was the sort of spirit that ought to be aroused; that was the true heuristic spirit. He profoundly agreed with Mr. Bentley in all he had said. If teachers could, somehow or other, get that spirit into a boy's mind they would have done more for him than they could do in any other way.

On the motion of the Chairman a vote of thanks to the author was carried unanimously.

OBITUARY.

The Right Hon. Sir William Grey Ellison-Macartney, K.C.M.G.—Sir William Ellison-Macartney, who was elected a Life-Fellow of the Royal Society of Arts in 1922, died at his residence in Chelsea, on December 4th, at the age of 72.

Born in Dublin in 1852, he was educated at Eton and Exeter College, Oxford, where he obtained a first-class in the school of Modern History. He was called to the Bar by the Inner Temple in 1878, and went the South-eastern circuit. In 1885 he was returned as Conservative member for South Antrim, a constituency which he represented for eighteen years. In 1895 he became Parliamentary Secretary to the Admiralty, and held that office till 1900, when he was sworn of the Privy Council. In 1903 he was appointed Deputy Master of the Mint and Engraver of His Majesty's Seals.

In 1912 he was sent out to Tasmania as Governor, being created K.C.M.G., and four years later he was transferred to Western Australia. On his return to London in 1920, he devoted himself to educational activities, becoming Chairman of the Governors of the People's Palace, Mile End Road, and a member of the Council of the East London College, University of London. He presided at a meeting of the Dominions and Colonies Section of the Society on December 7th, 1920, when Mr. A. H. Ashbolt, then and until recently Agent-General for Tasmania, read a paper on " Industrial Developments in Australia during and after the War."

NOTES ON BOOKS.

MODERN MASTERS OF ETCHING. Frank Brangwyn, R.A. With an introduction by Malcolm C. Salaman. London: The Studio Limited. 5s. net.

The publishers of this volume are to be warmly congratulated on their latest venture—a series of monographs on the modern masters of etching. The book under notice is the first of the series, and if the remaining volumes are in any way comparable to it, the publishers will have deserved well of their country. Each monograph will be in the form of a bound quarto; it will contain a critical appreciation of the etcher's work from an authoritative writer, and will be illustrated by photogravure reproductions of twelve of the finest plates of the master.

When we consider the price at which this monograph is sold, we can hardly find words strong enough to convey our admiration for the reproductions. The first is " The Storm," which, in addition to its artistic excellence, is further notable because it came like a bolt from the blue, and immediately established the claim of Brangwyn, hitherto known as a painter of genius, as a master etcher. An interesting account is given by Mr. Salaman of the almost accidental way in which this plate came to be developed from a comparatively commonplace etching to a masterpiece.

All the other works reproduced here are well-known to every admirer of Brangwyn, and we fancy that no one will quarrel with the selection made by the editor. It is a great joy to have within the same cover admirable reproductions of " Breaking up the 'Duncan'," " St. Peter's of the Exchange, Genoa," those two wonderful pieces " The Alcantara Bridge, Toledo," and " The Ponte Rotto, Rome," and that admirable study of scaffolding, which Brangwyn made when the Victoria and Albert Museum was being erected. Nor do we regret the inclusion of " Cannon Street Station." If every one could see the blots on the face of the earth with the eyes of a Brangwyn, what a beautiful place this world would be!

TRUSTS AND CARTELS IN GERMANY.

The movement towards combination, already marked in Germany before the war, and stimulated to a great degree by post-war difficulties, has continued, though in a modified form. The creation of large trusts, which was so prominent a feature of the last few years, appears to have ceased, at any rate temporarily, writes the Commercial Secretary to His Majesty's Embassy at Berlin in his recent annual Report, and has been succeeded by the less obtrusive alliances which are effected by the exchange of shares. It would be difficult to find a company of even moderate size in Germany which is not interested in this way in at least half-a-dozen others, with the result that the true distribution of interests is obscured to an extent which is baffling to the uninitiated. As distinct from the trust, those bodies known as unions, associations, or cartels, which regulate business conditions, prices, &c., for a number of firms or whole branches of industry, have lost both in popularity and in power owing partly to legislation which has been passed against them, and partly to the desire of the individual person or company to have greater freedom of action in times of difficulty. This is particularly evident in the Ruhr, where the coal, ammonia, tar and benzol syndicates have survived in a very loose form only.

THE HUMANE SLAUGHTER OF ANIMALS.

Giving the Third Benjamin Ward Richardson Memorial Lecture, under the auspices of the Model Abattoir Society, Dr. Chalmers Mitchell, F.R.S., Secretary of the Zoological Society of London, said that at the Zoological Gardens they had to provide meat for carnivorous and omnivorous mammals and birds. The animals chiefly used for this supply were horses and goats, and these were killed in a modern, hygienic abattoir. The rifle was used, and although on an average three horses were required in two days, he knew in the last twenty years of only two cases where a second shot had been required. They had tried "humane killers," but, at least for horses, had found no advantage in their use. He was quite certain that all methods of electrocution known at present required too elaborate a preparation, upsetting to the animals and dangerous to the staff, to be recommended. He had come to the conclusion that there was little or nothing to choose between the rifle and the humane killer, the pole-axe or the knife, skilfully used under proper conditions, as the instruments of actual death.

But there were many opportunities for carelessness, ignorance or inhumanity to inflict unnecessary suffering in the preliminaries to the final act. In his opinion these opportunities were least in the case of the rifle, relatively small with the humane killer, definite and probably nearly equal in the case of the pole-axe and the knife. If they were to be reduced to the absolute minimum, this could be done only in a large public abattoir with expert supervision.

In his opinion and experience animals had no presentiment of death, and to their consciousness even the fresh blood and warm offal of their fellows conveyed no message of fear. But they were readily thrown into panic by being driven into unfamiliar places and touched in unfamiliar ways by unfamiliar hands. He urged that every abattoir should have attached to it stables or byres of a kind to which they were accustomed, and that they should be kept in these for at least some hours before being slaughtered and be tended and finally led out by men familiar with the handling of living animals. There would then be the least chance of panic and, therefore, of accident in submitting them to the weapon employed.

ECONOMIC CONDITIONS IN FRANCE.

In his recent annual report dealing with economic conditions in France, the Commercial Counsellor to H.M. Embassy in Paris writes that the brilliant economic revival that ensued in the early months of 1922 has as yet suffered no eclipse. The entire population of France has continued in full employment, and her production has been consistently retarded by the dearth of labour.

The reconstruction of the devastated areas has been vastly accelerated, and for all practical purposes of mere industrial output it may be said to be terminated. The damaged or destroyed mines, which yielded fifteen hundred tons in January, 1919, yielded last May over 1,260,000 tons, and the total coal output of the area will soon exceed the pre-war figure. Not only have their general plant, coal-getting equipment, and power stations been immensely improved, but the efficiency of the industry has made immense strides by the increased or new provision for the output of all manner of by-products. In particular, a vital deficiency in the French raw-material production—her under-production of coke—has, under the spur of the cutting off of the Ruhr supplies, been so far repaired that France now produces at the rate of five million tons a year, or nearly two million more than in 1913. Her ore-mining industry has recovered ; her potash industry has got into its stride and is increasing its export to markets formerly possessed by Germany. The woollen, cotton, linen, and jute industries in these areas, all of which were severe sufferers in the war, have finished the re-equipment of their works, and have been producing to the full extent of their labour supply. The metallurgical, engineering, chemical, and miscellaneous industries of the same areas have likewise completed their reconstruction, and have been unusually active, especially since all misgivings relative to the coke, and therefore to the steel supply, were dissipated. Agriculture has made slower progress, partly owing to the still acuter shortage of labour ; but the chief crops—wheat and sugar-beet—are regaining their former productivity, and a certain progress is observable in providing the country with live stock.

Outside these areas the great trades have been, and are, equally prosperous. The Lyons silk trade, the lace trade at Calais and Caudry, the artificial silk trade, the Troyes hosiery trade, the Paris fancy article and luxury goods trades, the motor-vehicle industry in several centres, the watch trade at Besançon, the heavy chemical trades at Paris, Lyons, and elsewhere, the dyestuffs industry at Lille, Paris and elsewhere, the porcelain trade at Limoges, the bauxite production in the Var—these and the other great export trades all tell the same tale.

The prosperity of the country is amply attested by the constant stream of immigrant workers. For the last year the weekly arrival of about six thousand workers has been duly recorded ; the actual number has probably been much greater as coal miners and agricultural labourers, the two classes in greatest demand, may enter the country without having to pass through the official records. These immigrants are mainly of Italian, Polish, Belgian and Spanish nationality, but the most diverse nations are represented.

Apart from the prosperous dynamic state of the French economy, it may be also noted that it has increased in a permanent fashion its industrial capacity, which is now far superior, from the material and technical standpoints, to that of 1914. The natural resources have been increased by the acquisition of Alsatian ores, potash, and oil. Manufacturing power has been increased by the acquisition of highly developed and varied textile and engineering industries in Alsace, but far more through two main currents of expansion—namely, the wholesale reconstruction of nearly the entire range of textile industries, of coal and iron mines, metallurgical and engineering works, glass and chemical works, and so forth in the devastated areas, and the movement of transplantation of industry from these regions initiated during the war, which led to the employment of old or the establishment of new factories in the Lyons, Grenoble, Bordeaux, Rouen, and other localities throughout France. Moreover, as in certain other countries, employers tended to devote a considerable portion of war profits to the extension and improvement of works. As a consequence, French manufacturing industry as a whole has modernised and newly equipped its undertakings on a large scale.

As regards the consolidation of the great industries and the consequent better preparation for international competition the movement has made further progress. Several of the great metallurgical concerns which have increased their capital by large amounts have further extended their influence, whether in France, Holland, Poland, Czecho-Slovakia, Roumania, or Austria. The chemical industries witnessed a highly important amalgamation of their principal dyestuffs concern with one of the two dominating concerns in the heavy chemicals trade. The textile industry continued its rather slow tendency towards the emancipation of its undertakings from being family concerns into larger-scale company undertakings. The few leading electrical concerns further strengthened their domination and their manufacturing and distributing connexions. The shipping industry likewise witnessed further amalgamations.

The systematic development of the ports (including fishing ports), waterways, roads, not to forget water-power, was hampered through lack of funds. The great Rhine scheme, with its three-fold object of obtaining electric power, of making the Rhine navigable up to the Swiss frontier, and of irrigating the land, has not yet been put into operation; but the remarkable Marseilles-Rhone scheme, with its vast tunnel connecting the Mediterranean with the Etang de Berre and destined to provide a landlocked outer harbour for the heavier goods traffic of Marseilles, is being pushed forward steadily. The fishing port of Lorient is also nearing completion. The electrification of the railways is being actively pursued by two main systems, the Paris-Orleans and the Midi, as well as in the neighbourhood of Paris for surburban traffic; the Midi has made the greatest progress in this direction, so that within two years the long stretches from Toulouse to Biarritz and from Bordeaux to Hendaye will be terminated.

French foreign trade has been extremely active. It had already in 1922 surpassed its pre-war figures as regards weight. In the first six months of 1924 its exports exceeded those of the same period in 1923 by 2.3 million tons, the excess of manufactured products in that total having been 374,000 tons: for the same period imports were in excess by 2.5 million tons, entirely due to the imports of raw materials, manufactured products being less by 10,700 tons. Trade with Great Britain has made advance in raw material (France bought in 1923 18½ million tons of coal, coke and patent fuel, to the value of 2.2 milliards), but the imports of manufactured goods, such as textiles, special steels, etc., have been less. The question of the exchanges has continued to play a decisive part in Anglo-French trade.

Determined efforts have been made to deal with the serious condition of the public finances. Under the fiscal reform measures of last March provision is made for taxation which will yield about six milliards more revenue, retrenchment in the administrative services is estimated to produce a further milliard, and the borrowing powers of the State are reduced. The new taxation introduced in 1920 and having as its object to produce 8 milliards additional revenue, had already borne fruit, especially as regards the yield of income tax and other direct taxation. As a consequence of the two principal measures taken since 1914 to restore order in her finances, France will now be raising by taxation six times the revenue of 1914 and three times that of 1919.

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FRIDAY, DECEMBER 26, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

OPEN COMPETITION OF INDUSTRIAL DESIGNS.

The second annual Open Competition of Industrial Designs will be held in June next at the Victoria and Albert Museum, and full particulars can now be obtained on application to the Secretary of the Royal Society of Arts.

Competitions will be held in the following sections :—Architectural Decoration, Textiles, Furniture, Book Production, Pottery and Glass, and Miscellaneous. In addition to a large number of money prizes, Travelling Scholarships are offered in the Sections of Architectural Decoration and Textiles.

Under the head of Miscellaneous, several prizes of £50 each are offered by various firms for posters ; a prize of £25 is offered for a design suitable for the cover of a Christmas number of the *Graphic* ; prizes of £25 and £10 are offered for chocolate box designs ; and a prize of £25 for a design for a Christmas Gift Box.

It is intended to confer the Society's Diploma on any candidate whose work reaches a very high standard of artistic ability and also shows practical knowledge of the materials and processes of his trade.

After the work has been judged a number of selected designs will be exhibited at the Victoria and Albert Museum, and subsequently at suitable centres in the provinces. In this way they will be brought immediately to the notice of those manufacturers who are likely to be specially interested in them.

The Council hope to place the Scheme on a permanent basis and to offer annually travelling scholarships and prizes. In order to secure this object a very substantial capital sum will be required. They therefore appeal to all those who not only are interested in the artistic industries of the country, but are concerned for the general improvement of British trade to assist them in promoting the Scheme. Contributions to the Fund should be addressed to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

DR. MANN JUVENILE LECTURES.

Under the Dr. Mann Trust a short course of lectures adapted to a juvenile audience will be delivered on Wednesday afternoons, 7th and 14th January, 1925, at 3 p.m., by LIEUT.-Colonel E. H. RICHARDSON, on "Dogs in War" and "Dogs in Peace." The lectures will be fully illustrated with lantern slides, and by the dogs themselves.

Special tickets are required for this set of lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to tickets admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

Tea and coffee will be served in the Library after the lectures.

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "Colloid Chemistry" by Eric K. Rideal, M.B.E., M.A., Ph.D., D.Sc., F.I.C., have been reprinted from the *Journal*, and the pamphlet (price 1s. 6*d.*) can be obtained from the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures which have been published separately and are still on sale can also be obtained on application.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

INAUGURAL ADDRESS OF THE 171ST SESSION.

THURSDAY, DECEMBER 11TH, 1924.

SENATORE GUGLIELMO MARCONI, G.C.V.O., LL.D., D.Sc., Chairman of the Council, in the Chair.

THE CHAIRMAN presented the medals for papers and lectures given during the last session, and the Swiney Prize, as follows:—

Ordinary Meetings—

SIR FRANK BAINES, C.V.O., C.B.E., Director of Works, H.M. Office of Works, "The Preservation of Ancient Monuments and Historic Buildings."

SIR RICHARD ARTHUR SURTEES PAGET, Bt., "The History, Development and Commercial Uses of Fused Silica."

MAJOR-GENERAL SIR FABIAN WARE, K.C.V.O., K.B.E., C.B., C.M.G., Vice-Chairman Imperial War Graves Commission, " Building and Decoration of the War Cemeteries."

FRANK HOPE-JONES, M.I.E.E., Vice-Chairman, British Horological Institute, " The Free Pendulum."

BRIG.-GENERAL SIR HENRY P. MAYBURY, K.C.M.G., C.B., Director-General of Roads, Ministry of Transport, " The Victoria Dock District and its Roads."

T. THORNE BAKER, " Photography in Industry, Science and Medicine."

MRS. ARTHUR MCGRATH (Rosita Forbes), " The Position of the Arabs in Art and Literature."

SIR WILLIAM J. POPE, K.B.E., D.Sc., F.R.S., Professor of Chemistry in the University of Cambridge, " The Outlook in Chemistry." Trueman Wood Lecture.

Indian Section—

BRIGADIER-GENERAL H. A. YOUNG, C.I.E., C.B.E., late R.A., Director of Ordnance Factories, India, 1917-21, " The Indian Ordnance Factories and Indian Industries."

SIR RICHARD M. DANE, K.C.I.E., Commissioner, North India Salt Revenue, 1898-1907; Foreign Chief Inspector, Salt Revenue China, 1913-18, " Manu facture of Salt in India."

WILLIAM FOSTER, C.I.E., Historiographer, India Office, " The Archives of the Honourable East India Company." (Sir George Birdwood Memorial Lecture.)

Dominions and Colonies Section—

C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, " A Sketch of the Geology and Mineral Resources of Cyprus."

THE RIGHT HON. SIR FREDERICK LUGARD, G.C.M.G., C.B., D.S.O., D.C.L., LL.D., British Member, Permanent Mandates Commission, League of Nations, " The Mandate System and the British Mandates."

The Swiney Prize, consisting of a silver cup of the value of £100, and money to the same amount, was presented to Professor Sir Paul Vinogradoff, F.B.A., for his work, " Outlines of Historical Jurisprudence."

THE CHAIRMAN then delivered the following address :—

RADIO COMMUNICATIONS.

BY SENATORE GUGLIELMO MARCONI, G.C.V.O., LL.D., D.Sc., Chairman of the Council.

When a few months ago I was honoured by the invitation to become Chairman of the Council of the Royal Society of Arts, and was asked to deliver the Inaugural Address for the present session, I decided that the best thing I could do, within the limits of such an address, would be to confine myself to the subject with which I am best acquainted and to give you some short account of the latest and most important developments of Radio Communication.

This is a subject that has become so vast and so complex that you will readily understand my difficulty in deciding as to where I ought to begin and as to when I ought to stop.

So much is now generally known of the great strides which have lately been made in the practical applications of Radiotelegraphy and Radiotelephony, that it would be quite useless for me to descant at any length on many of its past achievements.

I therefore propose merely to deal with some of the difficulties which this new art has still to contend with, pointing out that, in my belief, the whole theory and practice of long distance wireless communication is just now undergoing a most important and somewhat radical change, and this, to my mind, only goes to prove that it is dependent upon phenomena in regard to which our understanding, to say the least, has been to a very large degree incomplete.

The subject is certainly fascinating for very many reasons, but also, perhaps, because electric waves are so far the only force which can be produced and controlled by man capable of being transmitted and detected over very great distances without the aid of any artificial conductor.

Neither the strongest conceivable light, nor the greatest fog horn, hooter, syren or loud speaker imaginable, or the explosion of all the explosives in Woolwich Arsenal, could possibly be seen or heard in America or Australia.

How is it that wireless waves will travel so far?

Many theories have been evolved to explain why it is that electric waves can reach these distant places and as to how they can bend right round the globe so as to be received with ease even at the Antipodes instead of shooting off into space.

A few years after my first experiments of Radio Transmission across the Atlantic Ocean, the late Lord Rayleigh stated in a paper read before the Royal Society in 1903, that the results I had obtained showed that the refraction or bending of the waves along the curvature of the earth was very much greater than what could have been expected by calculation.

The hypothesis which is now most generally accepted is that the waves are reflected by what is called the Heaviside Layer, which is supposed to be a conducting layer of rarified and ionized gases, constituting a kind of shell concentric to the surface of the earth, and capable of reflecting electric waves. This would go to constitute electrically a kind of curved ceiling, at a certain distance above the earth, capable of reflecting electric waves and resulting in these finding themselves enclosed between two concentric surfaces, from which they cannot escape.

Another theory, enunciated by Professor J. A. Fleming, is that the waves are reflected by a more or less sharply defined conducting upper layer of the atmosphere containing highly ionized dust flung off by light pressure from the sun.

A further explanation was suggested by Dr. W. H. Eccles in 1912. He referred to mathematical calculations which showed that an ionized rarified atmosphere is capable of increasing the speed of electric waves, so that if the ionization increases from the ground upwards, the top of the wave should travel faster than the foot and, in due course, should actually lean forward, thereby following the curvature of the earth.

These theories and hypotheses, together with others which I have not referred to, have never satisfactorily explained to my mind why waves of a certain length will cover great distances by daylight, whilst others will only cover similar ranges at night time.

During the course of tests carried out by me, between the wireless station at Poldhu in Cornwall and a ship in the North Atlantic as long ago as February, 1902, I then noticed for the first time the effect of daylight on the propagation of electric waves of about 2,000 metres in length over long distances.*

Although during night time I was able to receive signals up to a distance of 2,000 miles, during the day I failed to get them at 700 miles.

I subsequently discovered that longer electric waves, of the order of 10,000 metres or more, would on the average work as well by day as by night between England and America and other distant places, and up to now I believe that it has been universally accepted that short waves, whilst often giving extraordinarily long ranges by night, are incapable of being made to cover long distances during daylight.

As a matter of fact, for a period of about eight years from 1901, the Marconi Company had installed on a considerable number of ships a system of spark transmitters utilising waves of only 120 metres in length, which was commonly referred to as " Tune A." This system, although only utilising a very small amount of energy, was capable of regularly communicating over a distance of about one hundred miles during daytime, but at night the range often exceeded 1,000 miles, although a comparatively insensitive tape receiver was employed. One of the advantages of this system was its comparative freedom from atmospheric disturbances.

On the 2nd of July of this year I had the honour to read a paper before this Society on " Results obtained over Long Distances by Short Wave Directional Wireless Telegraphy," more generally referred to as " The Beam System."

In this paper I described the results obtained during many years of systematic research carried out by myself and by engineers of the Marconi Company with the object of evolving a practical directive system of Radio Communication.

I have always attached considerable importance to the solving of this problem, and I might recall the fact that during my earliest experiments carried out in England over 28 years ago, I was able to show to the late Sir William Preece, then Engineer-in-Chief of the Post Office, the transmission and reception of intelligible signals over a distance of 1-3/4 miles by means of an elementary beam system employing very short waves and reflectors, whilst, curiously enough, by means of the antenna or elevated wire system, utilising much longer waves, I could only at that time get results over a distance of half-a-mile.

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* Proceedings of the Royal Society (volume 70, 1902, page 344), " Effect of Daylight on the Propagation of Electro Magnetic Impulses over long distances." G. Marconi.

The progress subsequently made with the non-directional long wave system was, however, so rapid and the results so immediately applicable to practical purposes, that it very soon became, and still remains, what might be called the standard system.

I feel that it is regrettable that the study of short waves was neglected for a long period of years, for these waves which, so far, are the only ones that can be confined to narrow beams, are also capable of being employed to give practical results unobtainable by the lower frequency system which up to now has held the field for long distance communication.

The results obtained during my first experiments with directed waves were described by the late Sir William Preece in September, 1896, at the meeting of the British Association for the Advancement of Science and in a lecture he delivered at the Royal Institution in London on the 4th of June, 1897.

They were also referred to by me in a paper I read before the Institution of Electrical Engineers on the 3rd of March, 1899.

Most people may now agree with me that wireless waves are far too valuable to be always broadcasted in all directions, especially when it is desired to communicate only with one particular place, and I do not understand why, for example, messages which may be intended for Canada or South Africa should be scattered simultaneously pretty well all over the rest of the world, that is, over all the Continent of Europe, over Asia, South America, perhaps Australasia and New Zealand, not to speak of practically all seas and oceans.

I can well understand the utility of the non-directional stations for many Naval and Marine purposes, and, of course, for broadcasting ; but for ordinary efficient communication between fixed places, or between one country and another, I think the right and logical thing to do, if possible, both from the point of view of secrecy and of economy, is to concentrate all the radiated energy into a beam directed towards the country or place with which it is desired to communicate.

The number of available wave lengths is, after all, very far from being unlimited, and if a wave length which is being utilised for communicating between England and India should necessarily be allowed to spread to Africa and America it would most probably interfere with the free use of that wave in these other countries and also debar our use of that same wave for communicating simultaneously with them.

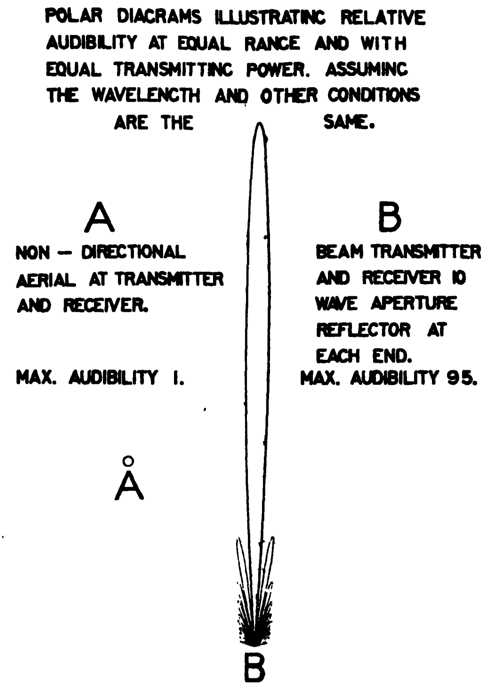
POLAR DIAGRAMS ILLUSTRATING RELATIVE AUDIBILITY AT EQUAL RANGE AND WITH EQUAL TRANSMITTING POWER. ASSUMING THE WAVELENGTH AND OTHER CONDITIONS ARE THE SAME.
A
NON - DIRECTIONAL AERIAL AT TRANSMITTER AND RECEIVER.
MAX. AUDIBILITY 1.
B
BEAM TRANSMITTER AND RECEIVER 10 WAVE APERTURE REFLECTOR AT EACH END.
MAX. AUDIBILITY 95.
Å
B

Fig. 1.

Figure 1 shows Polar diagrams illustrating relative audibility at equal range and with equal transmitting power, assuming the wave length and other conditions are the same.

A. Non-directional aerial at Transmitter and Receiver.

B. Beam Transmitter and Receiver 10 wave aperture reflector at each end.

When during the war, in 1916, I took up the systematic study of short waves, considerable doubt existed in my mind, and in that of other workers, as to whether the range of these waves might not prove to be too small for practical and useful purposes, particularly during day time, if they might not be altogether too unreliable and also as to whether large stretches of land and particularly mountains would not present absolute obstacles to their transmission over long distances.

The results obtained on short waves between 1916 and 1922 were described by Mr. C. S. Franklin in a paper read before the Institution of Electrical Engineers on the 3rd of April, 1922, and by myself in a paper read before the Joint Meeting of the American Institute of Electrical Engineers and the Institute of Radio Engineers in New York on June the 20th, 1922.

In 1920 experiments were carried out by Captain H. J. Round with duplex telephony on a 100 metre wave between Chelmsford and Southend, and the experiments were so successful that early in 1921 two stations which had been erected at Southwold and Zandvoort on the Dutch coast were put into commission experimentally, Southwold Station utilising about one kilowatt to the aerial.

Experiments were carried out, transmitting from these two stations to Norway in August, 1921, and at Christiansund day and night telephony was easily received from both stations. At Christiania, about 700 English miles, very loud and constant signals were received during the hours of darkness and in the daytime on certain days, apparently when the barometer was low.

During these experiments the curious night distortion of telephone signals was discovered, particularly when transmission was overland, the major cause of which has more recently been discovered by Captain Round in his work on Broadcasting.

Later, the results of these tests were merged into the general short wave beam experiments.

During the tests carried out on the steam yacht "Elettra" in the spring and summer of 1923, I was able to discover that the short waves I was then using could in fact not only cover great distances by day, and much greater distances by night, but that they were also quite reliable, and that, moreover, large parts of continents and ranges of mountains did not materially reduce their working distance. (Fig. 2.)

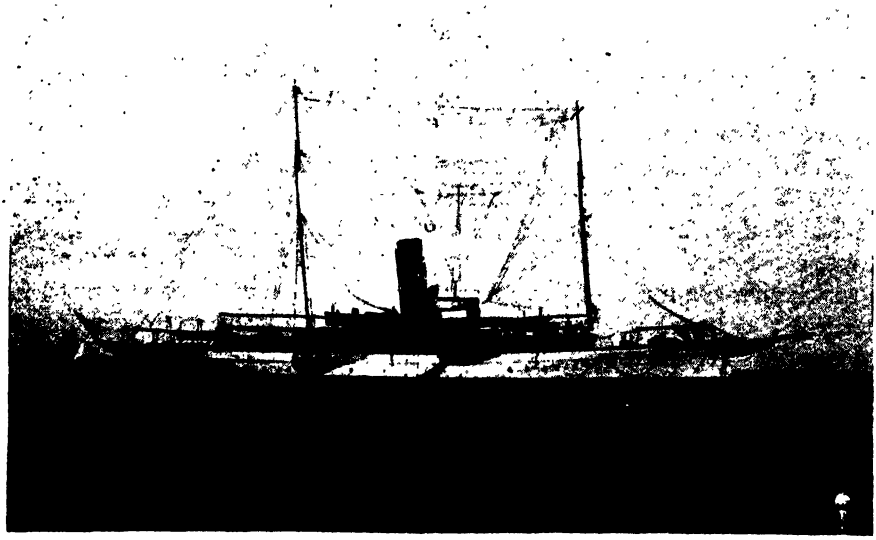

FIG. 2.

A series of tests was for the first time carried out with short waves over what might be termed world-wide distances during the winter, spring and summer of this year, between Poldhu in Cornwall and receiving stations situated on ships at sea and also at such places as Montreal, New York, Rio de Janeiro, Buenos Ayres and Sydney (New South Wales, Australia).

All these tests proved to be successful, including the first telephonic communication with Australia ever realised, although the amount of power utilised at the sending station never exceeded 20 kilowatts.

For a further and more detailed report of these tests and of the methods employed, and which I propose to employ, I would refer you to the paper read before the Royal Society of Arts on July 2nd, 1924, and published in the Journal of the Society of July 25th of this year, No. 3,740, Vol. LXXII.

Very strong signals were obtained at all these places during the hours when darkness extended over the whole distance separating each of them from Poldhu, and weaker signals for a few hours when the sun was above the horizon at either end, the intensity of the signals varying inversely in proportion to the mean altitude of the sun when above the horizon.

Although the signals were received with great strength at New York, Rio, and Buenos Ayres during the time when darkness spread over the whole or at least the major part of the great circle track separating these places from Poldhu, no signals at all were ever received, during these tests, when the same track or part of space was all, or substantially all, illuminated by the light of the sun.

While this limitation of the period of working to practically the hours of darkness constituted an undoubted disadvantage, still the economical advantages, together with the reliability and possibility of working this system, at far greater speeds than would have been feasible with the well-known high-powered long wave installations, went far to convince me that the short wave beam system would be capable of transmitting a far greater number of words per 24 hours between England and far distant countries, such as Australia, than would be possible by the comparatively powerful, cumbersome and expensive stations actually in use, or which were planned to be used, for Imperial commercial communications.

It is a satisfaction to me to be able to state that the stations intended for this purpose in England which we are now erecting under a contract with the Post Office, and others to be installed in the principal Dominions and far distant countries, will all be on the beam system.

Commencing in August of this year, a further series of investigations was carried out between Poldhu and the yacht "Elettra," the object being to endeavour, if possible, to find means of overcoming the limitation of working hours brought about by daylight, and also to test whether the effect of the reflectors would give the expected increase of signal strength over long distances.

The yacht proceeded to Spain, then to Madeira, and afterwards to Italy. From Naples we sailed for Beyruth in Syria, touching at Messina and Crete, and returning to Naples via Athens.

At Madeira it was ascertained that a reflector at the transmitting station increased the strength of the received signals in accordance with our calculations, but that, notwithstanding this increase of strength, when using a 92 metre wave the daylight range was only very slightly augmented.

At Madeira, and at other places, in the Atlantic and Mediterranean, comparative tests were carefully carried out with waves of 92, 60, 47 and 32 metres.

These tests enabled us to discover that the daylight range of practical communication over long distances increased very rapidly as the wave length was reduced, the 32 metre wave being regularly received all day at Beyruth, whilst the 92 metre wave failed to reveal itself for many hours each day, even at Madeira, notwithstanding the fact that the distance between Poldhu and Madeira is 1,100 miles, entirely over sea, whilst that between Poldhu and Beyruth is 2,100 miles, practically all over mountainous land.

Comparative tests on different wave lengths were carried out for a period of over two months in a variety of places, and all observations went to confirm the fact that for waves between 100 metres and 32 metres the daylight absorption decreased very rapidly with the shortening of wave length.

These results were so interesting and satisfactory that I immediately decided to try further tests over much greater distances.

In October of this year transmission experiments were carried out on a 32 metre wave from Poldhu to specially installed receivers at Montreal, New York, Rio, Buenos Ayres and Sydney (Australia).

Although the available power utilised at Poldhu was only 12 kilowatts, it was at once found possible to transmit signals and messages to New York, Rio and Buenos Ayres when the whole of the great circle track separating these places from Poldhu was exposed to daylight.

During a complete day transmission at fixed intervals carried out last October with Sydney, New South Wales, that station received the Poldhu signals for 23½ hours out of the 24, and a 48 hour test, which was only completed yesterday, fully confirmed this result.

The tests from England to places situated South of the Equator, such as Sydney, Buenos Ayres, Rio de Janeiro and Cape Town, are particularly interesting for the reason that the waves have always in these cases to traverse what may be called a summer zone, and are, therefore, subjected to an averaging effect of conditions, which can never possibly exist when the transmissions take place only between stations situated in the northern or southern hemispheres.

During November some successful receiving tests were carried out in England, from a low power transmitting station in Australia utilising waves of 87 metres.

During the present month of December trials have been continued with Canada, the United States, Brazil, the Argentine and Australia and, also, for the first time, with Bombay and Karachi in India and Cape Town in South

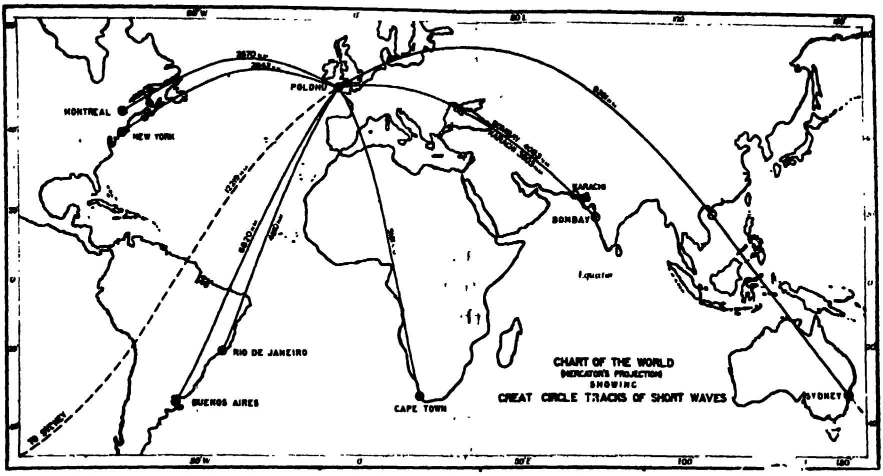

FIG. 3.

Africa. The power utilised at the Poldhu station during all these tests was 15 kilowatts.

Figure 3 is a map of the world, showing rough great circle tracks between Poldhu and various places where systematic receiving tests were carried out.

The results have fully confirmed my expectations in regard to the behaviour of the various wave lengths over such great distances, and I have no doubt that the information gained will render possible the installation of comparatively low power stations capable of establishing and maintaining commercial services by day and by night between England and the most distant parts of the globe.

The low cost of this system both in capital and running expenses, compared with that of the existing type of stations, must prove to be very great, and should bring about the possibility of a reduction in telegraph rates for all long distance communications, besides making direct communication with some of the smaller outposts of the Empire commercially remunerative.

Already the size and power of some of the most modern long wave stations was becoming a serious question from a financial point of view.

The newly equipped station at Buenos Ayres, for example, which was designed primarily for communicating with Europe over a distance of about 6,000 miles, employs 800 kilowatts and an aerial supported by ten towers each 680 feet high. This station usually works on wave lengths of about 12,000 and 16,000 metres.

Another example is the British Post Office Station, which is being erected near Rugby, which, when completed, will employ 1,000 kilowatts and an aerial supported by 16 towers each 820 feet high, and I might say that the station which we were erecting in the Union of South Africa was designed on a similar gigantic scale.

I am now firmly convinced that the Beam Stations employing only a small fraction of this power and much lower and fewer masts will be able to communicate at practically any time with any part of the Empire, and I cannot refrain from expressing my strong personal opinion that these powerful long wave stations will soon be found to be uneconomical and comparatively inefficient in so far as long distance commercial communications are concerned.

What remains now to be done is to complete the systematic study of these waves, especially in regard to their transit or propagation through space. They open up what I believe will prove to be a most fertile field for the investigator and an entirely new horizon to our view.

I do not propose at this time to attempt to suggest any theories or scientific explanation of the results obtained.

For some time the technical side of the art has been well ahead of theory. Although we have, or believe we have, all the necessary data for the generation, radiation and reception of electrical waves, as at present utilised for long distance communications, we are still far from possessing anything approaching an exact knowledge of the conditions governing the propagation of these waves through space.

If we had, we might perhaps have known before this that a wave about 30 metres long, utilising only 9 kilowatts in an aerial, could successfully travel to Australia and South America during daylight and there reproduce easily decipherable telegraphic signals.

I think that it will be admitted that these results indicate quite definitely that the well-known Austen formula is inapplicable to these waves. Another formula will have to be devised, based on the results of further investigations.

Reflectors of practical and economical dimensions are only efficiently applicable when short waves are used, and, although very long distances have been covered by these waves without the use of directional devices, I am convinced that these will be found to be essential for ensuring the carrying out of commercial high speed services. The disadvantageous effect called "fading" is sometimes a source of serious trouble when receiving signals transmitted by means of these waves, although much less serious than when waves of several hundred metres in length are employed.

According to our experience the use of reflectors diminishes fading, and also tends to overcome its effects by enormously increasing the strength, and, therefore, the margin of readability of the received signals.

Increasingly large and expensive reflectors could, of course, be used with longer waves than 100 metres, but the results of all recent tests seem to indicate that the shorter waves present the greatest advantages, one of the most important being that their reception is very much less liable to interference by the effects of atmospheric electrical disturbances, or "X's."

If these waves are destined to carry a considerable part of the most important long distance telegraphic traffic of the world, it may well be necessary in the near future, by international legislation, to regulate their use and safeguard them from preventable interference.

All the civilised world is now interested in what is called broadcasting, and in England alone over one million receiving sets have been licensed by the Postmaster-General.

The results obtained by amateurs have often been of great value in helping us to come to somewhat better understanding of the phenomena involved, and I might remind you that amateurs have recently been able to carry out two-way communication with New Zealand for brief periods.

It may well be that the day is fast approaching when the practical range of broadcasting will be enormously increased, and that American stations will be heard with clearness and regularity even during what lawyers call "reasonable times," that is, during the day and early afternoon.

At present, as everybody knows, one is usually obliged to listen for them very late at night or during the small hours of the morning.

It is also quite reasonable to expect that it will soon be possible for an important speech to be broadcasted even to the most distant parts of the Empire, irrespective as to whether it is made during day time or darkness.

The wireless transmission of pictures has already been effectively realised between New York and London. One would have to be very bold indeed to forecast what may be the future limitations of Radio Transmission.

I wish, before concluding, to express my very high appreciation of the work carried out by Mr. C. S. Franklin and his assistants in designing and operating the transmitting plant at Poldhu and for all the valuable work he has done in connection with short waves, and to Mr. G. A. Mathieu for the arrangements and management of the receivers on the yacht.

I also wish to thank the numerous engineers and experts and operators in Canada, the United States, Brazil, the Argentine Republic, the Cape, India, and last, but not least, Australia, for their most valuable co-operation in designing and working receivers, and in keeping long watches for the purpose of measuring the strength of the signals received from Poldhu in their respective countries.

DISCUSSION.

MR. ALAN A. CAMPBELL SWINTON, F.R.S. (late Chairman of the Council) in moving that a very hearty vote of thanks be accorded to the Chairman of the Council for his most interesting and important Inaugural Address, said the discovery Senatore Marconi had made, that while, as had been known for a considerable time, very long waves were better for long distance transmissions than moderately long ones, or what used to be called short ones, if the wave lengths were shortened to about 30 metres they were more applicable for long distance transmissions, was not only a very important fact, for the reasons the Chairman had pointed out, but it must also be borne in mind that it was possible to use reflectors with short waves, whereas with long waves the reflectors to be effective would have to be so enormous in size that their use was impracticable. It was a well-known optical fact that, in order to get optical reflection, the reflector must be large as compared with the wave length. Short waves enabled reflectors to be used, but they also possessed other advantages, because, as the Chairman had stated, they were less subject to interference by atmospherics. He wished to impress upon the audience that that was not only a very important discovery from a commercial point of view, but also from a scientific point of view, and he had been wondering what the professors would make of it! The Chairman had also alluded in the course of his Address to the possibilities of more extended broadcasting; in fact, broadcasting practically over the whole of the earth. Very probably some of those present had listened the previous evening to the broadcasting of music and speeches from America, the transmission being about the best of that kind that had hitherto been publicly accomplished. There was much less interference from atmospherics than usual. Atmospherics certainly existed, but apparently the fog, which was very bad at the time, was also bad for atmospherics. Another form of atmospherics also existed on that occasion, which probably some of those present had noticed had been referred to in the newspapers that morning. Somebody in the neighbourhood of London interfered very badly by producing most dreadful howls and squeals, due to the fact that the valve of his wireless apparatus was oscillating, and he did it so persistently, practically during the whole three-quarters of an hour that the transmission lasted, that it was scarcely possible to believe that it was not intentional. What was to be done with people like that? If a man persistently interrupted a concert at which about one thousand people were present so that he prevented them hearing the music, he supposed the individual in question would get a week's imprisonment. On the previous night it was quite possible that five million people were listening to the music and speeches broadcast from America, so that if the punishment was to fit the crime committed by the individual who made his valve oscillate, and thus interfered with the reception of the broadcast concert, he ought to be sentenced to five thousand weeks' imprisonment, or, say, one hundred years. He was afraid his righteous indignation against people who wilfully interrupted broadcasting had led him away from his subject, which was to ask the audience to accord a very hearty vote of thanks to Senatore Marconi for his most interesting and important Inaugural Address.

Sir Archibald Denny, Bt., LL.D., in seconding the motion, said that although he also did not possess the knowlecge which Mr. Campbell Swinton had in regard to the subject dealt with in the address, he thought all present would agree with him that the progress which had been made in the wonderful art dealt with had been extraordinarily rapid. He remembered that 26 years ago he had happened to be in Wellington, and was shown as a wonderful piece of apparatus a Marconi Coherer of that date, which he was told contained filings of a certain metal which was used for the reception of the signals. It appeared to him that the advance that had been made since that time was perfectly colossal, it having been made not in arithmetical, but in geometrical order. The advance in the knowledge in regard to short-wave transmission had been so rapid that, as was stated in the address, Senatore Marconi now held the firm conviction that the short beam system, with small power transmission, would be the system of the future. Those of the members who were interested in the second page of the "Daily Telegraph," which contained the commercial news of the day, would remember that one of the first statements made on that page was that "hot Treasuries" had been sold at so much during the previous day. The members of the audience had not received "hot Treasuries," but hot treasures from what the Senatore had told them, because he had referred to matters that had happened only on the previous day and previous night. He was sure not only the audience, but all the members of the Society, would desire to thank the Chairman for the service he had rendered to them by delivering such an interesting Inaugural Address.

The resolution was carried unanimously.

THE CHAIRMAN, after thanking Mr. Campbell Swinton and Sir Archibald Denny for the very kind remarks they had made, and the audience for the hearty manner in which they had been received, said a great deal had yet to be discovered in regard to the short waves that had been used for world-wide communication. It was not yet known which were the best conditions and the worst conditions for their use, nor whether they could be better employed during the night or the day, nor whether the fog might not be their friend. That was a matter for the future. He appreciated very much the kind remarks that had been made in regard to his address, and desired to conclude by congratulating most heartily the recipients of the medals and the Swiney prize, which he had had the honour of presenting.

ENCOURAGEMENT OF AGRICULTURE IN TURKEY.

According to a report by the British Commercial Secretary at Constantinople, the Turkish Government has taken some steps to encourage and assist the peasant of Anatolia, by the gratuitous distribution of seed and agricultural machinery.

In September, 1923, the National Assembly voted a credit of Ltqs. 1,100,000 for the purchase and distribution of seed, cattle and agricultural instruments to necessitous peasants. This credit having been exhausted in November, the National Assembly voted a further credit of Ltqs. 2,000,000 for the same purpose.

At the end of 1923 some 250 Fordson tractors had been sold in Turkey, mainly along the railway lines and coastal regions.

The Turkish authorities were also instrumental in encouraging the formation of co-operative societies with a view to intensifying production.

A special credit was also voted for the payment of reparation to peasants and others for Government requisitions effected during the military operations in Anatolia.

Although it has not been possible to obtain precise information as to the activities of the Agricultural Bank during the year 1923, it is known that large quantities of seed have been distributed to the peasants in Anatolia and Thrace.

The Government is also reported to be considering the revision of the present regime governing the rates and collection of the tithe, with a view to encouraging agricultural development.

ORGANISATION OF ELECTRICITY SUPPLY IN NORWAY.

The Commission appointed by the Norwegian Government in 1918 submitted last year to the Ministry of Public Works a technical plan for the organisation of the supply of electricity throughout the whole of Norway.

The Commission recommended that the supply of power for distribution from electricity works should be made a public enterprise, administered, under State control, by the various county councils and town councils. It is not, however, proposed to interfere with persons or concerns who have made or may make arrangements to procure electrical energy from their own power stations. Direct action in providing power is to be taken by the Government only in exceptional circumstances, as, for instance, in the case of Finmarken, where extraordinary conditions render it desirable that the State should assume responsibility for the whole electricity supply, but it is suggested that the State shall bear a certain percentage, varying in different parts of the country, of constructional costs.

The Commission have further drawn up plans for the supply of power to all railways in the South of Norway.

The report of the Commission has been submitted for consideration to the different town and county councils, and to the Board of Watercourses and Electricity.

According to a Report by the Commercial Secretary to H.M. Legation at Christiania, no operations which involve the harnessing of new water power were commenced in 1923. Work has, however, proceeded on the completion of State and municipal power schemes initiated at an earlier date, largely with a view to domestic service.

It may be mentioned as a characteristic feature of development during the past year, that much progress has been made in the establishment of inter-connexion between existing power stations, with a view to the best possible utilisation of energy which is already available.

GENERAL NOTE.

INDIA AT WEMBLEY.—According to the Allahabad correspondent of the *Times* the report of the Director of Industries of the United Provinces Government gives an enthusiastic account of the results of participation in the British Empire Exhibition. The sales up to the end of August amounted to nearly eight lakhs of rupees [£53,333], and the total is expected to reach 16 lakhs. Art wares were introduced to the widest possible circle of actual and potential buyers, new markets were opened, and an increasing flow of trade for years had been secured. Participation had spread a wider knowledge of industrial possibilities, and enabled Indian manufacturers and dealers to acquire first-hand knowledge of the tastes of foreign consumers. The Director of Industries of Bihar and Orissa also reports favourably, announcing that the sales of silk and lace had been considerable, and were limited only by the difficulty of executing orders.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, DECEMBER 29..Geographical Society, 135, New Bond Street, W. 3.30 p.m. (Juvenile Lecture). Major R. E. Cheesman, "Wild Life of the Arabian Desert."

TUESDAY, DECEMBER 30..Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C. 3.p.m. (Juvenile Lecture) Mrs. Scoresby Routledge, "Travels in the South Seas and Gambier Islands."
Royal Institution, Albemarle Street, W. 3 p.m. (Juvenile Lecture). Mr. F. B. Balfour, "Concerning the Habits of Insects." (Lecture II).

THURSDAY, JANUARY 1..Auctioneers' and Estate Agents' Institute, 29, Lincoln's Inn Fields, W.C. 7.30 p.m. Mr. E. W. Eason, "Compensation in regard to Re-Housing Schemes."
Royal Institution, Albemarle Street, W. 3 p.m. (Juvenile Lecture). Mr. F. B. Balfour "The Habits of Caterpillars."

FRIDAY, JANUARY 2..Mechanical Engineers, Institution of, (Midland Section). Chamber of Commerce, New Street, Birmingham. 7.30 p.m. Mr. A. W. D. Allister, "Notes on Engineering Publicity."
Geographical Society, 135, New Bond Street, W. 3.30 p.m. Dr. H. R. Mill, "Some Explorers I knew."
Geologists' Association, University College, Gower Street, W.C. 7.30 p.m. Miss M. S. Johnston, "Geological Sketches in Canada."

SATURDAY, JANUARY 3..Royal Institution, Albemarle Street, W. 3 p.m. (Juvenile Lecture). Mr. F. B. Balfour, "The Habits of the Dragon Fly."

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 7TH, at 3 p.m. (Dr. Mann Juvenile Lecture.) LIEUT.-COLONEL E. H. RICHARDSON, "Dogs in War.". (Lecture I.) LORD ASKWITH, K.C.B., K.C., D.C.L., will preside. Tea and coffee will be served in the Library after the lecture.

All the tickets for these lectures have now been issued.

OPEN COMPETITION OF INDUSTRIAL DESIGNS.

The second annual Open Competition of Industrial Designs will be held in June next at the Victoria and Albert Museum, and full particulars can now be obtained on application to the Secretary of the Royal Society of Arts.

Competitions will be held in the following sections :—Architectural Decoration, Textiles, Furniture, Book Production, Pottery and Glass, and Miscellaneous. In addition to a large number of money prizes, Travelling Scholarships are offered in the Textile Section, and also, thanks to the kind assistance of the Royal Institute of British Architects and of the Society of Architects, in the Section ofArchitectural Decoration.

Under the head of Miscellaneous, several prizes of £50 each are offered by various firms for posters; a prize of £25 is offered for a design suitable for the cover of a Christmas number of the *Graphic*; prizes of £25 and £10 are offered for chocolate box designs; and a prize of £25 for a design for a Christmas Gift Box.

After the work has been judged a number of selected designs will be exhibited at the Victoria and Albert Museum, and subsequently at suitable centres in the provinces. In this way they will be brought immediately to the notice of those manufacturers who are likely to be specially interested in them.

The Council hope to place the Scheme on a permanent basis and to offer annually travelling scholarships and prizes. In order to secure this object a very substantial capital sum will be required. They therefore appeal to all those who not only are interested in the artistic industries of the country, but are concerned for the general improvement of British trade to assist them in promoting the Scheme. Contributions to the Fund should be addressed to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

PETER LE NEVE FOSTER PRIZE.

The late Mr. Reginald Le Neve Foster presented the Society with a donation of £140 for the purpose of founding a Prize in commemoration of his father, Mr. Peter Le Neve Foster, who was Secretary of the Society from 1853 to 1879.

The Council have resolved to offer the Prize of £25 for an essay on " The Effect of Trade Union Regulations on Industrial Output."

Intending competitors must send in their essays not later than March 31st, 1925, to the Secretary, Royal Society of Arts, John Street, Adelphi, London, W.C. 2.

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on " Colloid Chemistry " by Eric K. Rideal, M.B.E., M.A., Ph.D., D.Sc., F.I.C., have been reprinted from the *Journal*, and the pamphlet (price 1*s.* 6*d.*) can be obtained from the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures which have been published separately and are still on sale can also be obtained on application.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, DECEMBER 5TH, 1924.

Professor HENRY E. ARMSTRONG, Ph.D., LL.D., D.Sc., F.R.S., in the Chair.

THE CHAIRMAN said it was a great privilege to be permitted to introduce Colonel McCarrison to the meeting. Colonel McCarrison had been a long time in India and for a good many years on the Northern Frontier. During the last dozen years or more he had been actively engaged in inquiries into food problems.

The paper read was:—

"PROBLEMS OF FOOD, WITH SPECIAL REFERENCE TO INDIA."

By Robert McCarrison, C.I.E., M.D., LL.D., D.Sc., F.R.C.P.,
Lieutenant-Colonel, Indian Medical Service.

The problems of food, to which it is my privilege to direct your attention this afternoon, relate to quantitative faults in the dietaries of human beings and to their connexion with disease. And since such problems are many and diverse, I propose to devote the time at my disposal to a consideration of some of those having a special concern for India, in the investigation of which I have been engaged for some years past.

The known essential constituents of food are proteins, fats, carbohydrates, mineral elements, vitamins and water. These provide materials for the production of energy and heat, for the replacement of tissue waste, for maintaining the proper medium in which the chemical reactions of the body can take place, and for making these chemical reactions possible. The body requires these essentials in definite quantity and proportion one to another, and in regard to some of them in definite quality also. So it comes about that the normal chemical reactions on which nutrition depends may be disturbed by reason either of the excessive ingestion of certain of these food essentials, or by the deficient ingestion of some, or by a combination of food deficiencies with food excesses. Further, one essential constituent of the food may be rendered relatively deficient by the excessive ingestion of another. Thus we have in diabetes, as it occurs in India, an example of a malady arising in consequence of the over-consumption of starch and sugar combined with lack of exercise; in beri-beri we have an example of a malady associated in its origin with the deficient ingestion of another food essential belonging to the vitamin class; and in a certain form of thyroid derangement we have an example of a malady which may arise from relative deficiency of iodine consequent on the excessive ingestion of fats or lime.

Of all the essential constituents of food, none is more remarkable than the group to which the name " vitamins " is applied; it is around these substances that most of my remarks will centre. They were called "vit-amines" because they are essential to life, and were at one time thought to be related in chemical composition to the nitrogenous substances known as amines. And although this view as to their chemical composition is now known to be erroneous, yet the name to which it gave rise has remained; the terminal " e " in the word " vitamine " having of late been dropped, so that the resulting word no longer suggests a substance of a defined chemical composition. The term " vitamin " is now so well known that it would be difficult to displace it, and it serves perhaps as well as any other. Vitamins are remarkable because little or nothing is known of their chemical composition; because the normal chemical processes of the body are impossible without them;

because their quantity in the food is infinitesimal both in proportion to other food essentials and to the profound influence which they exercise in nutrition; and because their discovery, revealed by feeding experiments on animals, provided a new concept of disease production. Prior to their discovery we had thought of disease as being capable of production only by some positive agent, such as a microbe or a toxin; subsequent to their discovery it was realised that disease might also arise from negative causes, such as the deficiency in the food of substances essential to the harmonious regulation of life's processes. It was natural that at first "deficiency diseases"—as those states of ill-health are called which are caused by deficiency of certain constituents of the food—should have been limited to those associated with deficiency of vitamins, these being the first to engage the attention of investigators. But later it became apparent that vitamins were not the only food constituents whose deficiency would give rise to disease. Want of proteins, of iodine and of other essentials are now known to be capable of causing "deficiency diseases." But the problems connected with these diseases do not end with the insufficient intake with the food of certain substances essential to normal metabolism. Questions arise as to their inadequate assimilation or absorption; their relative insufficiency in relation to other food constituents; the varying needs of the body for them under different conditions of life; and the interaction of such food deficiencies with other disease producing agents.

Important then as "vitamins" are, it is not to be assumed that their importance outweighs that of any other essential constituent of the food, nor that the new concept of disease to which their discovery gave rise eclipses in importance the knowledge we already possess in regard to disease-production by positive agents. As our knowledge of disorders due to food deficiencies increases, it will, I think, be found to dovetail more and more into that already acquired in regard to positive pathogenic agents. There is no antagonism between the older and the newer knowledge, rather is there a close interdependence between them. I make these comments because there is a tendency in some quarters to extol the importance of vitamins at the expense of other equally important food constituents, a tendency in others to pooh-pooh their influence in nutrition. We hear on the one hand that so long as the food contains enough vitamins little else matters; on the other that provided it be varied enough the vitamins will look after themselves. Both these views are extreme views and both are wrong. Man may consume a diet which contains abundance of vitamins, yet it may not contain enough fuel materials for his energy requirements, nor enough nitrogenous material for the adequate repair of his tissues; while variety in the foodstuffs used may yet fail to provide a sufficiency of vitamins, unless the knowledge we possess as to their distribution in nature is made use of to guide us in the proper selection of food materials.

If animals be fed on a chemically pure diet composed of proteins, fats, carbohydrates, salts and water in proper quantity and proportion, they will not thrive nor survive. But if vitamins be supplied, as by the addition of a little milk to this diet, they will grow and flourish. This was, indeed, the classical experiment of Gowland Hopkins : the root from which our knowledge of these remarkable substances has sprung. The inclusion of vitamins in adequate quantity in an otherwise complete diet enables the other essential elements of the food to be properly utilised ; without a sufficiency of them the normal chemical processes of the body are impossible. I have likened their action to that of the spark which ignites the fuel mixture of a petrol-driven engine liberating its energy : the spark is no use without the fuel nor the fuel without the spark : if either be wanting the engine will not run.

Both man and animals derive their supply of vitamins directly or indirectly from the vegetable kingdom : from those sources to which reference is made in the first chapter of Genesis : " from herbs bearing seed and from every tree in the which is the fruit of a tree yielding seed . . . and from every green herb." Certain animals are able to obtain from these sources alone all the materials—proteins, fats, carbohydrates, mineral elements and vitamins—requisite for their perfect nutrition. To enable them to do so they must eat these vegetable foods in very large quantities, and nature has endowed them with gastro-intestinal tracts capacious enough for the purpose. But man, whose gastro-intestinal tract is less capacious than that of herbivora, cannot obtain from vegetable sources alone all the food essentials for his energy requirements, nor for the attainment of the highest degree of physical efficiency. He can obtain a sufficiency of certain essentials, such as carbohydrates, mineral elements and vitamins from vegetable sources, but it is necessary for him to supplement the diet of seeds, tubers, roots, vegetables and fruit with a certain amount of animal food. Carnivora, again, do not make use of vegetable foods, from which vitamins are derived ; they are thus dependent for their supply of these substances on the tissues of animals that do, and in which they are present in quantities which vary with the particular tissue.

The foodstuffs available for the use of man are roughly divisible into the following groups :—

(1) Seeds, tubers and roots.
(2) Fruit and green leafy vegetables.
(3) Muscle tissue of animals.
(4) Glandular organs of animals : liver, kidney and the like.
(5) Milk and milk products.

The storage parts of plants, comprising the first group, are incomplete foods, because they are deficient in the right kind of protein for man's needs, in essential mineral elements and in certain vitamins associated in nature with fats. They are, however, the great source of carbohydrates ; the cereals—wheat, barley, rice, etc.—being the staple food of man. In the second group, including fruit and green leafy vegetables, vitamins and essential mineral constituents are plentiful, but energy-bearing constituents are scanty. The third group, which includes the muscle tissues of animals, is, like the storage parts of plants, deficient in certain vitamins and mineral elements, but it provides the right kind of protein. The glandular organs included in the fourth group are rich in vitamins of all classes and in mineral essentials; in this respect, being comparable to the growing parts of plants, in which active metabolism is taking place; these organs also provide the right kind of protein. Milk and milk products, which make up the fifth group, are rich in all those elements and complexes in which the storage parts of plants and muscle meat are lacking. The perfect diet is, therefore, one in which these different groups of foodstuffs are so combined that the defects of one are made good by the richness of another in those essentials wherein the first is lacking. A diet of cereals, tubers and roots, even when supplemented with muscle meat, is not a complete diet, for the reasons given. This diet is one in common use by many people in this country. It may be rendered satisfactory by the liberal inclusion in it of green leafy vegetables and fruit. It will be more satisfactory still if the cereal used—whether wheat or rice—be not deprived of much of its value by refined milling processes; if, in short, whole meal bread be used instead of white bread or unpolished rice instead of white rice. But the diet will be most perfect when liberal amounts of milk and milk products, with or without muscle meat, are used to supplement the cereals, tubers, fruit and vegetables which compose the bulk of it.

There is, perhaps, no country in the world where the truth of this doctrine of nutrition is more convincingly illustrated than in India. No one who has travelled far in India can have failed to observe the remarkable differences in physical efficiency of its different races; and although there are a number of factors, climatic and other, which play their part in determining these differences, yet there can be no doubt that nutrition is the chief among them. The common foodstuffs available for use by the people of India are mostly derived from the vegetable kingdom: they include rice, maize, barley, wheat, millet, legumes, vegetables and fruit. These form the food of millions of Indians; animal foods, milk and milk products being made use of, as a general rule, only by the better classes and by certain races of Northern India. The commonest and the worst of all diets in use by Indians consists of rice, legumes, vegetables and condiments. This diet is poor in protein, in certain mineral elements and in certain vitamins; and consistent with these defects we find the users of it to have the worst physique, the lowest powers of resistance to bacterial infection and the worst health of any of the races of India. Another diet in common use in India is made up of wheat, with or without rice, legumes, vegetables and condiments. It is largely used by the people of the United Provinces. It is a better diet than the rice-legume one because wheat provides a better protein and more of it, and while it is deficient in certain respects (as in vitamin A) it is less so than the rice-legume diet. Consistent with the better quality of this diet we find the physical efficiency and general wellbeing of its users to be of a higher order than that of the users of a rice-legume diet. It is, however, when we come to races like the Rajputs, the Sikhs and the Pathans, who supplement the diet of cereals, legumes, fruit and vegetables with animal foods, especially milk and milk products, that we meet with the highest degrees of physical efficiency to be found in Oriental races, or, indeed, in any races of mankind. The diet of the Sikhs is a lacto-vegetarian one. It consists of whole meal flour, legumes, tubers, vegetables, fruit and clarified butter, with abundance of the milk of buffaloes, cows and goats. Their children are breast-fed for two-and-a-half years, the mother's milk being supplemented during the last year of lactation with the diluted milk of cows or goats. Throughout life the Sikhs use milk and milk products freely, buttermilk and curds being largely consumed. They eat meat at times: two or three times a month, perhaps, but it is a luxury rather than a necessity, and has not the same important place in their diet as milk and milk products. It would be difficult to conceive of a diet which more adequately fulfils the functions of food than that of the Sikhs. The milk which forms so important a part of it provides protein in the best and most assimilable form, as well as all those elements and complexes which are deficient in the vegetable part of their food. Those who are familiar with the Sikhs will be slow to admit that for courage, manly qualities and general physical efficiency they are surpassed by any other race of mankind.

The diet of the Pathans is much the same as that of the Sikhs, but they are greater meat-eaters, and they too are among the finest races of mankind so far as physique is concerned. For many years my work brought me into close contact with another race which is unsurpassed in perfection of physique and powers of endurance. I refer to the people of the Hill State of Hunza in the extreme North of India. The diet of these people corresponds in many ways to that of the Sikhs, but they eat less meat, and, their stock being limited to goats, their consumption of milk and milk products is less than that of the Sikhs. But they are great fruit-eaters, especially of apricots and mulberries, which they use in both the raw and the sun-dried state. The powers of endurance of these people is extraordinary: to see a man of this race throw off his scanty garments, revealing a figure which would delight the eye of a Rodin, and plunge into a glacier-fed river in the middle of winter, with as much unconcern as many of us would take a tepid bath, is to realise that perfection of physique and great physical endurance are attainable on the simplest of foods, provided these be of the right kind. These people are long-lived and vigorous in old age, Among them the ailments so common in our own people—such as gastro-intestinal disorders, colitis, gastric and duodenal ulcer and cancer—are extraordinarily uncommon, and I have no doubt whatever in my own mind that their freedom from these scourges of modern civilisation is due to three things: (1) their use of simple, natural foodstuffs of the right kind; (2) their vigorous outdoor life; and (3) their fine bracing climate. It is some years now since I drew attention to the freedom of these people from many of the maladies which so commonly afflict our own people, and found a reason for it in their use of unsophisticated foodstuffs. I take this opportunity to repeat this statement, and to suggest that if a closer study of the food habits of different races of mankind were made, we should find as much material on which to base sound judgments as to the origin of many common diseases as we now find within the four walls of the best equipped laboratory. The examples I have given you will suffice to show that the physical efficiency and wellbeing of any race is largely a matter of the food they eat. It is not only because the diet of the Sikh contains more suitable protein than that of the Bengali although this is a matter of great importance —nor because it contains more vitamins, that the Sikh excels the Bengali in physical efficiency and wellbeing, but because the diet of the Sikh contains *all* those elements and complexes necessary for the maintenance of perfect nutrition. Each essential constituent of food is a member of a team on the co-ordinate action of which perfect nutrition depends.

I am tempted at this point to diverge from my consideration of food problems as they relate to India, in order that I may draw comparisons, not always to our own advantage, between the food habits of our own people and those of Indian races. I might draw your attention to a diet in such common use in this country as that consisting of white bread, potatoes, muscle meat or tinned meat, margarine and jam, and point to its incompleteness and incapacity to sustain normal metabolism in every individual using it, or refer to the scanty part that such nutritious foods as milk, fruit and green leafy vegetables play in our dietaries. I might urge the necessity of providing these foods—the protective foods, as McCollum has called them—in greater abundance, and at prices within the reach of our own people, or draw pictures of the physical inefficiency and mal-being which their lack entails, but I shall content myself by remarking that all I have said and all I have to say in regard to India has a bearing of no less importance for the people of these islands.

I now turn to provide specific examples of the effects on the animal organism of faulty food deficient in vitamins, and for this purpose I select rice from among "the herbs bearing seeds," since it is a cereal widely used in the dietaries of Indian peoples. It has long been known that the too exclusive use of rice is often associated with the occurrence of a disease known as beri-beri. This malady is endemic in certain parts of India; it is characterised by a paralytic condition of the limbs, by wasting and dropsy, or both, by cardiac enlargement and other features too technical for mention. In common with all other cereals, but in major degree, rice has certain defects as a food: its protein is poor in quality and scanty in amount; it is lacking in fats and in vitamins associated in nature with fats, and it is lacking in certain essential mineral elements. To begin with, it is an incomplete food, and this incompleteness is enhanced in greater or lesser degree by the manner of its preparation for human consumption. Its faults as a staple food are compounded of the faults inherent to it as a cereal, and of those that are superadded to them by the various milling and refining processes to which it is subjected. The association of rice with beri-beri is, however, related rather to the superadded faults than to those inherent to it as a cereal.

The rice grain, or *paddy* as it is called in India, consists of a central core of starch and the germ of the seed surrounded by a thin red outer coating, the whole enclosed in the husk. The husk is first removed by thrashing, and thereafter the red rice is subjected to various refining processes, all of which deprive it to a greater or lesser degree of those parts of the grain (the germ and outer layers) in which the major part of the vitamins occur. These processes also deprive it of part of its proteins, fats and essential mineral elements in which the rice grain is at best poor. The simplest practice is to pound the rice by hand in large mortars. This has the effect of removing little of the vitamin-containing tissues, and the result is a " red rice," which, as you will presently see, is the best of all forms of rice in use in India. The method is a good one also, because it is customary to pound only a sufficiency of the paddy for a day or two's use, so that it has little opportunity to deteriorate as decorticated rices have when stored after milling. The second procedure is to parboil the paddy first and pound it afterwards. Parboiling consists in first soaking the rice in water and thereafter subjecting it for 15 minutes or so to the action of steam: it is subsequently dried in the sun and is then ready for pounding or milling as the case may be. The effect of the parboiling is to cause the outer layers of the rice grain to adhere, so that when pounded by hand or milled and polished in modern rice mills, more of the vitamin-containing tissues are retained, and a rice of better nutritive quality, in some respects, is secured. But while parboiling preserves to the rice-grain much of its original store of one kind of vitamin (that known as the anti-neuritic vitamin or vitamin B), it robs it of much of its original store of another kind of vitamin (that known as fat soluble vitamin or vitamin A because of its association in nature with fats). It does so because the parboiling and subsequent drying of the rice in the sun preparatory to milling subjects this vitamin A to oxidation, to which it is very susceptible; so that parboiling, which is advantageous in one way, is disadvantageous in another. The third procedure is to mill the rice in native or modern rice-mills, either in the raw or in the parboiled state. The germ and more or less of the outer vitamin-containing layers are removed in the process, according to the degree of milling and polishing to which the rice grains are subjected. Rice may, therefore, be of at least five kinds: (1) Raw, home-pounded unpolished rice; (2) parboiled, home-pounded unpolished rice; (3) parboiled, milled and *lightly* polished rice; (4) parboiled, milled and *highly* polished rice ; and (5) raw, milled and *highly* polished rice. In the experiment, the results of which I now show you, you will see the effects of these different

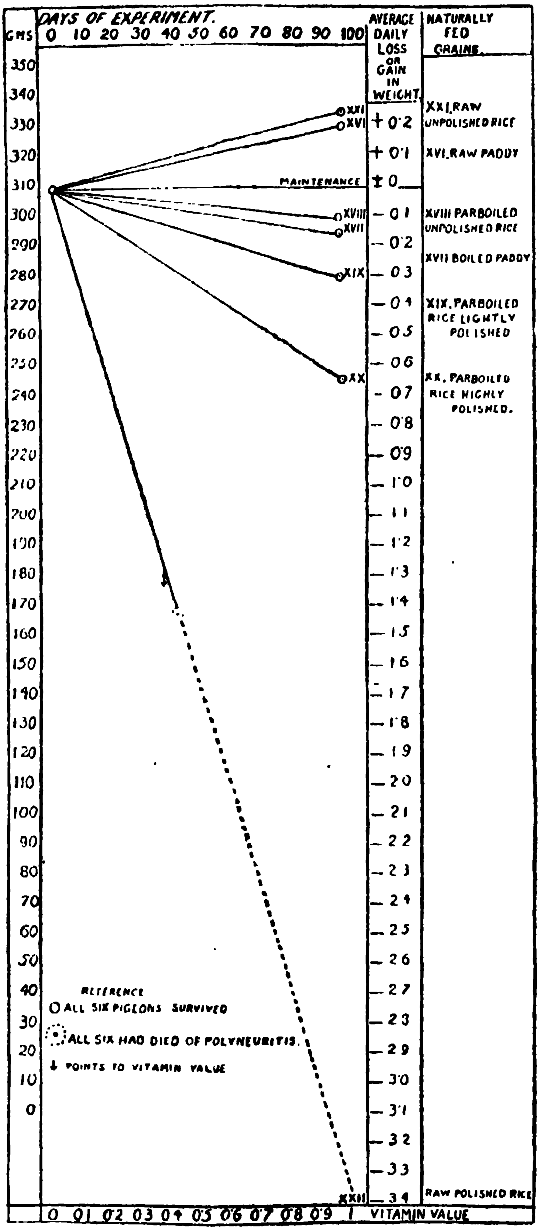

Diagram showing the effect of parboiling, milling, and polishing on the nutritive and vitamin values of paddy as determined by feeding groups of six pigeons on the various products.

rices on pigeons fed exclusively upon them I obtained from Tanjore a quantity of paddy of a certain well-known and much used variety. This was specially treated for me in the five ways above mentioned. I obtained from the same locality a large number of pigeons of approximately the same age and strain (it being a matter of the first importance in such an experiment as this that every conceivable factor which might tend to complicate the results should be excluded as far as possible, the birds used should be from the same locality, and of the same age and strain and so on). The pigeons were divided into seven groups, having six birds in each group, in such a way that the total weight of the six birds in each group was the same: 1,860 grams, or an average weight per bird of 310 grams. To each of five groups one or other of the five kinds of rice was given as their exclusive food; the sixth group received as its sole food the original paddy in the raw state; the seventh group the original paddy in the parboiled state. In the chart now shown you will observe that each group started from the same point, as indicated by the average weight of the birds—310 grams. The birds were weighed weekly, and their average weight charted so as to give what we call "weight curves." For the sake of clearness I show you these weight curves as straight lines. Now notice what happened to the birds during the 100 days the experiment lasted. Those which received the raw, home-pounded unpolished rice put on weight, so that at the end of the period of 100 days they exceeded in weight that of any other group. Next in order came those which received the raw paddy: their weight was not quite so good at the end of 100 days as that of the first group; no doubt, because they had to eat a considerable amount of the less nutritious husk adherent to the paddy. Third in order were those which received the parboiled, home-pounded, unpolished rice: their weight fell below the line of maintenance, a line at which the amount of vitamins and other food constituents in rice is so nicely balanced that the average bird neither gains nor loses in weight. Fourth in order came the group which received the parboiled paddy. The next three groups show the effect of milling and polishing; the fifth group had a parboiled lightly polished rice, the sixth a parboiled highly polished rice, and the seventh the raw polished rice; the loss of weight in each group being proportionate to the degree of polishing. The effect of parboiling in preserving to the rice grain certain important food essentials is well seen by comparing the weight curves represented by the last two lines on the chart. Both rices were subjected to the same degree of milling and polishing, but the parboiled rice lost much less of some essential necessary for maintaining the weight of the birds than did the raw rice. This raw milled and polished rice is in use by millions of the people of India. Notice what happened to birds fed exclusively upon it: they lost weight rapidly, so that by the 40th day, when all of them had died, they had lost almost one-half of their original weight. If you compare their weight curve with that of the first group you will see how profound is the effect of milling and polishing of rice. The first group had the raw unpolished rice and gained in weight; the seventh group had the raw polished rice and they lost weight rapidly and died within 40 days. This result is due, in the main, to the removal by milling and polishing of the germ and outer layers of the rice grain in which the major part of the essential vitamins are stored. This is what modern machinery does in reducing the food value of rice. It makes the milled product a positive danger to its users. Some of you may say "Thank goodness, we do not live on milled and polished rice." But many Europeans do live largely on white flour, and if my experiment had been carried out with wheat instead of with rice it would have given the same result. There is much to be said for the *Daily Mail* slogan: "The whiter your bread the sooner you're dead." For unless the deficiencies in white bread or in white rice are made good by the consumption of other foodstuffs, rich in those elements and complexes in which these materials are lacking, physical inefficiency and disease will inevitably result. Clearly, it is folly to use a product, whether it be of rice or wheat, which is deprived in the process of manufacture of food factors of vital necessity to the body. Whole meal and unpolished rice are not deprived of these factors; therefore these should be eaten in preference to white flour and polished rice. I might show you other charts in which this effect of milling and polishing of rice was prevented by giving to the birds the rice polishings in addition to the highly polished rice, but in that case the result would be practically the same as that represented by the first line in this chart.

You will notice that the birds represented by the lines marked XVIII, XVII, XIX and XX lost weight, but none of them died within the 100 days of the experiment. The fact that none of them died was partly good luck, but more because of the precautions I took to prevent any kind of infection reaching them; and, fortunately, none of the birds were "carriers" of any infecting agent. If such infection had reached them, or if any among them had been "carriers" of an infecting agent, deaths from this cause would have occurred. I don't want you to go away with the idea that it was only the group which was fed on raw polished rice that was in any danger of death or of disease; the other groups, whose weight-lines fell below the line of maintenance, were in danger also, although this danger was not so great. They were in danger from infections, and the only groups which were not in great danger from this cause were the two groups which lost no weight. It is of the utmost importance to realise that if there be not enough vitamins, suitable protein, and essential mineral elements in the food of man or beast to prevent the weight dropping below the line of maintenance, then disease is not far off.

Now let us return to the condemned group shown in the last line of this chart. You will see an arrow on this line pointing downwards: it is placed at a point which represents the average number of days taken by the six pigeons to die of a malady called *polyneuritis columbaram.* This malady, as its name implies, is a disease of the nerves, which is due to the want of the specific vitamin removed in the milling and polishing of rice. This vitamin has, therefore, been called "the anti-neuritic vitamin" (a term which has of late been shortened into "vitamin B") because of its power to prevent this form of neuritis in pigeons. You will notice that this group was the only one in which the disease occurred. The polished rice eaten by these birds did not contain enough of the vitamin to prevent polyneuritis, whereas in the other groups the intake of the vitamin was sufficient to prevent it. I now throw upon the screen some examples of this malady in pigeons and fowls.

It needs no description from me to indicate the state of paralysis in which these birds are. If now one takes a bird in this state and gives it a certain amount of rice polishings or of egg-yolk or of peas, all of which contain this anti-neuritic vitamin in abundance, the effect is miraculous. Within three to six hours of receiving the missing vitamin the bird will (unless great damage has been done to other tissues than the nerves) be up and about, flying around one's laboratory. In the whole range of experimental research work there is nothing more marvellous than this. To see a bird helpless and paralysed, having fits at regular intervals, in which it turns cart wheels backwards for yards over one's laboratory floor, take to its legs and wings within a few hours of receiving the missing ingredient of its food, is a sight which ought to convince the most sceptical of the value of experimental research. Some of you will probably say that the nerves of such a bird cannot have been vastly injured, otherwise it could not recover so completely in so short a time. This is true: the nerves are not vastly injured, but they won't conduct impulses from the higher centres efficiently, and the higher centres themselves cannot transmit efficiently. But provide the missing vitamins and their loss of function is practically restored to normal. Now what is the bearing of all this so far as man is concerned? The disease known as beri-beri, which affects man, is similar in some ways to this malady in pigeons, although it is not identical with it. Beri-beri has long been known to be associated in man with the too exclusive use of over-milled rice. The effect of this rice in producing polyneuritis in pigeons suggested that it probably had the same effect in man, and that beri-beri, which is also a polyneuritis, might be due to the want of the particular vitamin removed in the milling and polishing of rice. We know now (at least some of us do) that beri-beri is not due solely to want of this vitamin, but we know also that a well-balanced food, which is rich in it, will prevent beri-beri in man, cut short outbreaks of it, and even cure it in those who suffer from it. It is a malady which we have now the power to control.

But the complexity of the problems which confront the investigator of disease is well illustrated by this malady. It would be so satisfying to feel that it is due solely to the want of a certain vitamin or vitamins in the food, so comforting to know that we had to do only with one factor in its causation. But this is not the case. No one, even in India, lives only on polished rice, however great may be its proportion in the diet. It is always supplemented with other foods, usually with legumes. Now no rice-legume diet in common use by the people of India will cause polyneuritis in pigeons, yet the qualities of this diet are not such as will prevent beri-beri arising in man in those localities where the disease is endemic. I know of localities in India where beri-beri has prevailed for years before rice milling was introduced into India, and where the disease occurs among the users of raw home-pounded or parboiled rice, neither of which will, as a rule, cause polyneuritis in birds. Their food contains enough anti-neuritic vitamin to prevent this malady in birds, but not enough of it to prevent beri-beri in man. The conclusion has been forced upon me that in localities where beri-beri is endemic there is some other undiscovered factor which is its essential cause, and the operation of which is prevented by the use of a diet which contains the so-called anti-neuritic or anti-beri-beri vitamin in abundance, as well as all the other essential requisites for perfect nutrition.

Another result of the assumption that want of this vitamin is the sole cause of beri-beri is that the label "anti-neuritic" has been attached to it, thereby limiting our outlook in regard to the functions of this substance in the animal organism. So long as we think of it as being "anti-neuritic" only we cannot conceive of its having any other function to fulfil than to keep the nervous tissues in health. But it has an importance in regard to other tissues of the body as well as to the nervous tissues, and this importance is as great, if not greater, than the other. No cell of the body, whether it be nerve cell or secretory cell, or muscle cell, can adequately perform its function unless there be a sufficiency of this vitamin in the food. The cells concerned with digestion and absorption of food are dependent upon it for their proper action, those concerned with secretion, whether the secretion be that of milk or an internal secretion, such as that provided by an organ like the pancreas, are dependent upon it; and the sooner we cease applying to this vitamin such restricted terms as "anti-neuritic" or "anti-beri-beri" the better.

Now I shall show you what is likely to happen to the gastro-intestinal tract and to the organs of digestion in animals, whose food is lacking in this vitamin, and has the other faults found always in diets where this vitamin is lacking. There is an idea abroad that faulty foods in common use are faulty only because they contain too little vitamins. This is a great mistake. The faults of such foods are not confined to vitamins alone, but include others, such as excess of starch or sugar or both and deficiency of essential mineral elements. The results I have now to show you are due to the combination of food faults which are so commonly to be found in the dietaries of Europeans as well as of Indians. One of the chief effects of such faulty food is to bring about gastro-intestinal disease, and when it is remembered that no less than one-quarter of all those who seek relief at our great hospitals do so for gastro-intestinal disease, it will be realised how vastly important is the knowledge that faulty food deficient in vitamins is the chief cause of it. One of the earliest effects of a diet of polished rice is to cause diarrhœa or dysentery. The tract becomes the prey of pathogenic bacteria or other pathogenic agents which it may happen to contain. The long-continued use of food deficient in vitamins gives rise to atrophic and degenerative changes in the cells which produce the digestive juices, in those also by whose means food is absorbed; so that the food is not so well digested or assimilated; it undergoes fermentation and putrefactive changes with the production of toxic substances, which in their turn contribute to the mal-being of the patient. A vicious circle is thus produced. Further, it causes atrophic and degenerative changes in the neuro-muscular mechanism, which controls the movements of the gastro-intestinal tract, so that dilatations occur in various parts of it, colitis is set up, and ultimately the muscular walls and their nervous control become so impaired in function that difficulty arises in emptying the bowel of its contents. So constipation is brought about, and that very common condition to which Sir Arbuthnot Lane has given the name chronic gastro-intestinal stasis. In monkeys and guinea-pigs fed on such faulty foods I have even observed ulcers of the stomach and duodenum which have arisen in consequence of it, and on one occasion I found a recent cancer of the stomach in a monkey so fed which I suspect may have originated—indirectly, no doubt—in the same way. These being among the effects of faulty food deficient in vitamins, you will understand why the people of Hunza, to whom I have referred, whose food has not these faults, are so remarkably free from gastro-intestinal ailments.

In my opening remarks I referred to the pancreas—an organ having a great deal to do with digestion and also with the utilisation of sugar by the body. If certain cells of this organ become diseased or atrophied, sugar passes out of the body and diabetes results. From these cells a substance is now prepared, which is called "insulin," and when it is administered to persons suffering from diabetes the disease is in many cases held in check. Now great as is this advance in the treatment of diabetes, it is not sufficient to control this malady. It is necessary to know how these cells of the pancreas, whose function it is to control the metabolism of sugar, become inefficient. Diabetes is very common amongst the rice-eating classes of India if their habits be sedentary, and especially if they eat largely of sweetmeats. Now one of the effects of a rice diet is to cause atrophy of these cells of the pancreas, on whose functional perfections the normal metabolism of sugar depends. This atrophy is due very largely to chronic lack of vitamin B in the food, and it seems not improbable that chronic lack of this vitamin, together with the excessive consumption of polished rice and sugar by persons of sedentary habits, may prove to be among the chief causes of diabetes.

These, then, are some of the effects of faulty food deficient in vitamins in causing states of ill-health, but a number of other factors come into play in determining the production of disease under conditions of faulty nutrition. One of these is individual idiosyncrasy. Nothing has been brought home to me more clearly in the course of my experimental work than the fact that one animal's meat may be another animal's poison. Some animals may do quite well on a diet on which others fail to flourish. Some may actually gain in weight on a diet which causes loss of weight in the majority. Some remain free from disease; others on the same diet develop divers diseases, and die. There is no knowing which animals will suffer and which will escape when the food is deficient in vitamins, but not wholly lacking in them. If it be wholly lacking in them all animals suffer alike. But in practice, and so far as man is concerned, it rarely or never is wholly lacking in them. In man it is with insufficiency of vitamins in an otherwise ill-balanced diet that we are mainly concerned, and not with complete want of these vitamins. So that in experiments on animals our great concern should be to find out what happens to them when their food contains an insufficiency of these vitamins, but is not devoid of them. The truth is we know enough already about the effects of their complete want, but not enough about the effects of their insufficient supply. The problem always reminds me of that of want of oxygen. Few suffer from complete want of oxygen, and if they do this want is brought about by accidental causes, but many suffer from partial want of oxygen. So it is with vitamins.

As an example of how different animals may be affected in different ways by the same faulty food, I now show you a chart illustrating an experiment in which different effects were produced by the same rice diet in three pigeons. The rice used in this experiment was a "beri-beri-producing" rice: it was the actual rice in use by sufferers from this malady, and was, in fact, a par-boiled rice which was not markedly deficient in anti-neuritic vitamin. It was given to these three pigeons as their exclusive food, the control pigeons being fed at the same time on a well-balanced diet of mixed grains. The birds were adults. You will notice that the controls on good food did not suffer in any way, but the three pigeons on the rice diet all behaved differently. No. I. at first gained in weight for 10 days, then it lost weight rapidly, and died on the 35th day from invasion of its body by micro-organisms derived from its gastro-intestinal tract. The poor food caused this bird to become the victim of a pathogenic agent, of which it was itself the "carrier." The second bird was apparently unaffected by the rice diet and did not even lose weight. The third developed "beri-beri" from which it died on the 57th day. It, too, was the "carrier" or the producer of some agent which imparted beri-beri-like characters to the polyneuritis resulting from a rice diet. I could give you many illustrations of a like kind, but this will serve to emphasise the varying effects of the same faulty food, which may be observed in different individuals.

The greatest of all disease-producing agents which come into operation when the food of animals or of man is deficient in vitamins and faulty in other regards are pathogenic organisms (bacterial and other). When one takes a number of animals and desires to observe the effects upon them of a deficient food, the conditions of the experiment are not precisely alike in each individual, even though the faulty food given to them be the same, and the conditions of life under which they live during the course of the experiment be the same. The conditions of the experiment would only be the same if all the animals used were like so many clean test-tubes, into which we put certain reagents, expecting to get the same reactions in all. We sometimes do get the same reactions in many of the animals, but often we do not, and for this reason, among others, that no group of animals is like a group of clean test-tubes. In fact, they are more like test-tubes which already contain other and varying ingredients that are likely to complicate our reactions. Their intestinal tracts, for instance, may contain bacteria or other pathogenic agents of widely different character. In this connexion one experiment on wild monkeys impressed me greatly: a number of these animals were confined in the same room, each in its own cage. Some were given a well-balanced natural food, rich in vitamins, others the same food, which had been subjected to prolonged heat in the autoclave, in order to destroy these vitamins. The first group remained in perfect health: the second, on the vitamin poor food, showed many examples of amœbic dysentery. I found that some of the monkeys which received the good food were "carriers" of the amœba which is associated with this form of dysentery, but whereas they were protected from dysentery by the good food, those receiving the vitaminless food developed it. There were in the room in which the animals were confined equal chances for all to become infected with the dysentery-producing organism—the same flies, the same animal attendants, the same dishes, but the determining factor in the production of this malady was none of these things, but was faulty nutrition. This observation has a very important bearing on the question of the high incidence of dysentery in the jails of Bengal. The effects of faulty food may, therefore, vary with the different distribution of pathogenic agents in different individuals; but the fortuitous intervention of pathogenic agents in causing disease under conditions of faulty nutrition is not only a question of the distribution of these agents in different individuals, but is also a question of the geographical distribution of such agents. I have often given the same faulty food to animals obtained from different localities, and found that they developed different maladies depending on the particular pathogenic agents which they happened to have brought with them from their respective places of birth. Before I left India I succeeded in producing a malady in pigeons having all the characters of true beri-beri in man, but this malady appeared only in birds obtained from a locality where the human disease occurred: it did not appear in others obtained from a locality where the human disease did not occur, although the latter were fed on the same rice as the former. The distribution of beri-beri as an endemic in India is a very limited one : it has not extended its endemic borders during the last 100 years, although many millions of people outside these borders habitually use a rice-legume diet which is as faulty as that used by people within these borders, who develop beri-beri. Peculiarities in the geographical distribution of pathogenic agents, whether these be bacteria or poisons, is, I believe, very important in relation to the morbid effects associated with faulty food. But perfect nutrition serves to control the operation of these agents, so that in a locality where beri-beri is endemic the best way to escape it or to recover from it is to use a well-balanced diet, rich in those vitamins with whose insufficiency in the food this disease is associated. The worn tread of a motor-car tyre makes puncture of the inner tube inevitable, but it is the discarded hob-nail from the labourer's boot, or other similar agent, which causes the puncture ; and while the worn tread may travel far in some localities without encountering a hob-nail, it will travel less far in others. The best way to escape puncture is to keep the tread perfect : so it is with perfect nutrition and the pathogenic agents of disease.

Before bringing my remarks to an end, I may mention another problem in regard to food which is of great interest. It is this : Does the nutritive and vitamin value of cereals vary with the conditions of their growth ? During the course of an exhaustive inquiry into the food value of the various rices in common use in India, I had reason to suspect that such might be the case. I found that various paddies varied considerably in their nutritive values. I could find no reason for this in their chemical composition. So it occurred to me that it might be due to differences in their content of vitamins, *i.e.*, of substances which are incapable of detection by chemical means. Such differences might, I thought, be brought about by differences in soil or manure, or other conditions of growth of the grains. It was not possible to put this conception to the test in the case of rice, but it was possible to do so if I used millet, which is another staple grain largely used in India. Accordingly, Dr. Norris, Agricultural Chemist to the Madras Government, had nine of the experimental plots at the Agricultural Farm, Coimbatore, sown with the same millet seed. These plots have been in existence for 15 years or so and have been manured in different ways. One had no manure at all all this time ; another was manured with nitrates ; another with phosphates ; another with potash ; others with various combinations of these, including one which received a complete chemical manure ; the ninth plot had been manured with the natural manure of cattle. When the time came these various plots were cropped, the crops weighed and samples from each crop analysed by Dr. Norris. There were the usual variations in quantity of the crops, and the usual differences in chemical composition associated with different forms of manuring, but the chemical analysis provided no consistent evidence that the nutritive value of the different samples might vary because of variations in certain chemical constituents of the grain. When I came to test the quality of these grains by feeding experiments on animals, I found that the millet grown on soil manured with natural cattle manure was more nutritious and contained more vitamins than that grown on soil manured with artificial manure ; that grown on an exhausted soil being the worst of all in these respects. I was in the middle of this work when my researches came to an untimely end owing to financial retrenchments in India, so I was not able to repeat the experiments, nor to extend them to other grains. I wish, therefore, to be very guarded in drawing conclusions from them, but it does seem that the nutritive and vitamin values of millet seeds depend on the manurial conditions of their growth. This observation opens up a field of investigation which may prove to be of great importance, not only for India, but for other countries.

The considerations I have raised in the course of this paper will have shown you how wide is the net which the study of nutritional problems casts: physicians, surgeons, dentists, specialists in every branch of medicine, veterinary surgeons, pathologists, chemists, physiologists, bacteriologists and agriculturists are embraced by it ; and each can contribute something to the solution of these problems. But they are the concern also of teachers in our schools, and of statesmen, who by spreading the knowledge already acquired, or by its application, can do much to improve the physical efficiency and well-being of our peoples. There is often so much in the results of scientific research that has not always an immediate applicability to the good of humanity. The newer knowledge of nutrition is not amongst their number. I would urge on the young profession of medicine in India to study these problems of nutrition for themselves, for they lie at the root of many of the diseases by which their vast country is afflicted.

DISCUSSION.

The Chairman (Professor Henry E. Armstrong), in opening the discussion, said he thought all would agree that Colonel McCarrison's address was of great public importance, not only full of meat, but of milk and vegetables, too. One often talked of the ' ills that flesh is heir to," but the probability was that many, if not most of those ills were conditioned by faulty feeding, and it was to be feared that the food of to-day was not so good as the food of years ago, before the introduction of cold storage and of canned articles of diet. Milk was poorer in average quality, though now improving ; bread was poor ; a large proportion of the meat was poor in quality—it was less palatable because of the system of cold storage, whereby natural changes were prevented which formerly were allowed to take place, during hanging, before the joint was cooked ; too much of our food was canned ; probably we drank far too much tea and many people smoked too much tobacco. Another article in food not sufficiently considered which probably had slight effect upon the public health was the antiseptic. He was seriously of opinion that the antiseptic most used but generally regarded as a very mild one was the most dangerous in the long run—boric acid. The extent to which boric acid was put into our food was very serious. He spoke not merely from a general point of view, but from his own experimental observations and knowledge of the extraordinary chemical activity of boric acid. Colonel McCarrison's paper should be regarded as of immediate importance in connexion with the inquiry which the Government was instituting through an agricultural conference into our national food policy. One party was advocating that we should abandon pasture or at all events that we should lay down a much larger proportion of our land to the growth of cereal crops. Those who knew something of the condition of the pasture land in England were aware that much of it was very poor indeed in quality. His own feeling was that the issue ought also to be looked into from the alternative point of view of bringing our pasture land up to the highest level possible and producing as much good meat and good milk as possible, so placing the land in such condition that we could, at any moment, if necessary, grow potatoes and cereals on it, the while we should get all the wheat we could from abroad and be long sighted and put capital into the soil in the form of phosphates, so developing our land with an eye to the future. Our position with regard to the supply of vegetables was a wicked one. The meeting had heard from Colonel McCarrison that everything we knew tended to support the opinion he had put forward, that fresh vegetable food was of primary importance. Every housekeeper knew that no part of our food supply was more difficult to obtain in a proper condition or was more expensive. The supply was in the hands of a class of people who were of the lowest type among traders. They did their work, in a way, with extraordinary efficiency, but the status of the trade was low, and the supply of vegetables was not what it should be: it was often stale, and there was great waste, as producer and consumer were too far apart. The public attitude towards vegetable food, especially uncooked vegetables, was not what it should be. One might go where one would on the Continent, the fresh salad was a necessary constituent of the chief meal; it was not a necessary constituent of our English diet, and in this country we ate relatively little fruit. We had never yet learned to feed rationally. In the old days, when we lived in the country, we were fed magnificently, but town conditions had altered the state of affairs altogether.

The subject was one of extraordinary difficulty and the Society was to be congratulated upon having the problems of diet brought before it by one who had had so broad an experience and had been able to collect his evidence over so wide an area among so many peoples. Only the previous week he (the speaker) had been reading a book by Dr. McGovern, describing his walk to Lhasa through Tibet. The account given in that book of the food eaten by the villagers was very remarkable, in great contrast with what Colonel McCarrison had stated to be the habits of the Kashmir peoples. The Tibetans regarded milk as an unclean material and would not drink it; neither chickens nor eggs were eaten. The people lived on raw yak meat, barley meal and tea. The water had to be boiled and drunk as tea to make it safe. They had neither vegetables nor fruit. Yet the people did well on such a diet—doubtless because they ate raw meat. In this country we made the mistake of cooking all our meat, even our milk. It would be better if we ate our beefsteak raw, as the Germans used to do.

Colonel McCarrison had raised a very important question, at the close of his paper, in his reference to the possible influence of manurial treatment on the quality of crops. There could be no doubt that there was a difference in food materials produced under conditions of incomplete manuring; they had not the quality of those produced when the plant had a whole diet. The problem was one which was very difficult of solution and it was much to be deplored that, at the moment when Colonel McCarrison's inquiry was becoming of such importance, his work should have been closed down. He had had to lament from that platform, before that day, in connexion with Indigo, the attitude of the Government of India with regard to problems of the kind. The instance which Colonel McCarrison had brought before the meeting was only another illustration of the fact to which he had already called attention in that room, only two days previously, that we were making no proper public use of science to-day: scientific method did not enter into politics nor into government. If politicians had any conception of the value, especially to a country like India, which was so poorly fed, of inquiries of the kind described in the paper, they could not possibly, for a moment, contemplate the discontinuance of work such as Colonel McCarrison's. The subject was one, however, which required workers of a far less academic type than those who had dealt with it hitherto. It required to be dealt with from the broad point of view which Colonel McCarrison had displayed, and it was to be hoped that, now the subject was assuming public importance, it would be treated in a more suitable way. Only the previous day there was a paragraph in the *Times*, calling attention to the publication of a White Paper from the Home Office dealing with the diet of children, in which Dr. Culverwell said that parents ought to include all the milk and the vegetable food they could afford in their children's diet.

It had been hoped that the Secretary of State for India, Lord Birkenhead, would be able to attend the meeting; unfortunately he had been prevented, owing to absence from London. Sir Arthur Keith, who also was unable to be present, in his letter of regret referred to Colonel McCarrison's discoveries as of "great value." Fortunately, there were several present who could speak from experience and with authority.

SIR WILLIAM H. WILLCOX, K.C.I.E., C.B., C.M.G., M.D., F.R.C.P., expressed his admiration not only of the brilliant paper which Colonel McCarrison had just read, but also of his work during many years, which had culminated in that paper and others of a similar kind. The subject of diet was one in which he (the speaker) had for many years been interested, and during the war it was his lot to serve in the two campaigns in which deficiency disease was most prevalent—namely, in the Dardanelles, and, for three years, in Mesopotamia, where he supposed a larger number of cases of scurvy occurred than had ever been recorded previously in the world's history. He regarded the paper as of great value, not only on account of what Colonel McCarrison had done and what he had taught those interested in the subject, but also because he had altered the conception of the whole question of diet. It was he who first showed that if animals were fed on inadequate diet, not only did they suffer from malnutrition, and might die from that cause, but were predisposed to diseases. The diet altered the power of resistance to disease, and the animal which was badly fed suffered in the functioning of all the organs which produced the secretions necessary for good health—the endocrine glands. Colonel McCarrison was, he thought, the first to point out that defective diets led to errors in the glands themselves and in their functioning. In Mesopotamia the British troops were fed on a dietary which did not include fresh vegetables and fresh milk, as they were unobtainable. The diet consisted of bread and biscuits made of the sort of flour we all ate to-day—the highly milled flour—and jam and tinned meat. In that diet, especially owing to the flour, the vitamins which gave protection from beri-beri were absent; therefore, the British troops developed beri-beri. They were able to get a certain amount of fresh meat, and that apparently protected them from scurvy. As he had pointed out in a paper in 1919, the British troops had a better balance in the bank when they arrived there. The vitamins were more or less cumulative in the body, so that if we lived on the right kind of food we stored up enough vitamins to serve us for several days. For that reason the British troops were more resistant than the Indian troops. The Indian troops were living on atta (whole-meal flour), dal (lentils); and they did not like meat. That diet, though protective against beri-beri, was scorbutic. In 1916 something like 20,000 cases of scurvy occurred among the Indian troops, and he had had an opportunity of seeing and classifying a very large number of those cases. That experience confirmed in a very marked manner what the reader of the paper had told them. He wished to ask Colonel McCarrison whether the present diet of the Indian soldiers was similar to that before the war; in February, 1917, a ration was issued which was practically the same as the Indian troops had before the war, and had the property of causing scurvy. Many people in England to-day were suffering from defective diet, and there was no doubt that that diet predisposed to disease, to improper physical development and to defective teeth; it was also associated with defects in fecundity. Legislation could not proceed in advance of public opinion. Therefore, it was necessary to educate public opinion. He had recently had an opportunity of going over one of the best flour mills in this country. In a sack of corn there was an extraordinary collection of stones, excretal matter, and all sorts of things. Those foreign bodies were got rid of, and then there was the wonderful process of milling. It was perfectly marvellous how the various constituents of the wheat grain were separated out. He had asked why the millers produced the defective flour of which Colonel McCarrison had spoken. The answer was that the public would not have anything else. When a campaign was started in certain newspapers there was a demand for whole-meal flour, but after a few days it became unpopular, and the millers would very soon be in the workhouse if they did not supply the particular kind of flour which had been condemned.

SIR CHARLES H. BEDFORD, D.C.L., LL.D., D.Sc., M.D., late I.M.S., said that Colonel McCarrison was the greatest living exponent of the causation of goitre, and his work on the various deficiency and other diseases had filled them with admiration, especially considering the difficult conditions under which work in India was often carried on. In order to educate public opinion in this matter of correct diet, it was necessary that medical men, who must necessarily guide public opinion, should agree and express clear opinions on the subject. Those opinions, he took it, did not exist to-day, and the general principles should be enunciated by some body of such authority—for example, the Royal Society or the Royal Society of Medicine —that it could co-ordinate the scientific worker and the practical clinical worker. Unfortunately, professional opinion on the subject of dietetics was in a somewhat chaotic condition. He thought most well-informed doctors were clearly of the opinion that the "living foods," such as uncooked vegetables, were of great importance. He would like to ask Colonel McCarrison whether he had ever had occasion to examine a postulate which was very frequently stated, especially in American text-books, as regards the mixing of starchy foods with proteins, sugar or fruits. That was anathema to a certain type of dietists. They said that one might eat starches, vegetables and salads, but one must not eat proteins or fruits. Why? Such points as that needed clearing up in an authoritative fashion. The Chinese had a proverb which we might do well to lay to heart, especially in this country—"Look to the mouth : diseases enter there." A very large number of our diseases were due to a badly-balanced diet, *i.e.*, one seriously defective, qualitatively and quantitatively, in the relative proportions taken of the chief food groups (proteins, carbohydrates, fats, salts, etc.). Any Government which neglected the conditions of the food supply of the country was neglecting its duty gravely ; therefore, his plea was for a better standardisation and a greater popularisation of our knowledge on the subject, and on that basis should be built a great educational campaign. He personally would look to Colonel McCarrison as one of the guides in such a campaign.

COLONEL W. G. KING, C.I.E., late I.M.S., said that Colonel McCarrison had ended his highly interesting address by exhorting research workers to investigate nutritional problems—expert workers concerned both with man and beast. That meant that up to 1924 from the date when Adam ate his first apple, there had been no full experience of what mankind should eat. There had, however, been collected a vast deal of practical experience, and so far as the individual was concerned no doubt the old saying was applicable—" One man's meat is another man's poison." The history of the Crimean and Boer Wars showed the necessity for the co-ordination of scientific and practical knowledge. The troops were sent to the Crimea on a diet inferior to that of the garrisons at home, and our troops were sent to the Boer War on a diet less than that of criminals at home. As regards India, it was a fact that the Madras jails were run by the East India Company and under the Government up to 1866 entirely on a rice ration. No doubt, without due investigation either of the science of matter or of the habits of the people, it was concluded that Indian diet was rice. The result was a mortality in the large jails of 107 per mille. Surgeon-General Cornish had investigated the diet of the natives for the benefit of the British Association, which had initiated an enquiry in India on the subject. He represented to the Government the error of conducting those jails on a diet of rice, although the natural diet of five-sixths of the population of the Madras Presidency at that time was dried grain. From 107 per mille the death-rate went on an average of eight years to 22 per mille. In the 1876-8 famine in India a great authority in the Government of India insisted that one pound of dry grain per day was sufficient for adults. That was in a famine which cost, ultimately, a decrease of 3¼ millions in the population. In contrast they had the fact that before hostilities commenced in the Great War the ration for the British soldiers was not only scientifically but practically tested. In India many years ago Henry King had found what Colonel McCarrison had said—namely, that grains on soil which had been deprived of nutritive power became toxic. Lieut.-Col. Sir Walter Buchanan had set to work to try and educate the Bengalis who passed through his jail that a combination of wheat and rice was much better than a plain rice diet. Last, but not least, Colonel McCarrison, on joining the Indian Medical Service and ever since, had worked independently in a magnificent manner, with results that were well known, not only with reference to goitre but to dietetics generally.

In India geographical distribution of races bound by religious or caste rulings limited choice of nutriments at all times, whilst under unfavourable meteorological conditions such restrictions aggravated scarcity to the threatening of life amongst millions of people. The very Budget of the Government of India had been pronounced a " gamble with rain." In such a country, it should be evident that were the work of the solid character effected by Colonel McCarrison in relation to human beings co-ordinated with the excellent scientific research efforts of the Agricultural Department of the Government of India, it could not fail to be of both humanitarian and financial benefit to the country. Yet, Colonel McCarrison told them that, owing to financial retrenchment by that Government, his researches had been abruptly closed. Here, again, the "practical man" with his conception of the triviality of scientific research had interposed and decreed indefinite delay—just as occurred in the case of Sir Ronald Ross when dealing with the great malaria problem. Could the gain by retrenchment in this case be reasonably balanced against the loss of important research results—advanced almost to the point of completion? So long as Colonel McCarrison was on the cadre of the now moribund Indian Medical Service, his full pay must be forthcoming whatever his employment. Presuming the Indian Research Fund could not meet the charge, the extra strain upon Government finances would be a small percentage of that pay; for the rest, his current laboratory expenses would be met. It seemed most impolitic to have interrupted valuable work by a specialist to effect so small an economy, If ultimate recovery of funds so expended was essential, in the next famine were the Government of India to so far utilise present day advance in dietetics as to issue in the Provincial Famine Codes a table of calories for the standard diets, based on the nutrient value of the respective grains relied upon, instead of indiscriminately prescribing the same weight throughout India—without relation to such values—they would recoup the expenditure a thousand-fold, and prevent the possibility of inequable treatment of famine-workers according to areas inhabited. Both those who had scientific research at heart as well as those who would aid the welfare of the people of India—more especially of the almost voiceless agricultural labourer—might well regard it as a matter of duty to utilise any influence they might possess to require the revoking of a decision—the only reasonable excuse for which was that it was arrived at during a period of temporary panic occasioned by a defective Budget.

COLONEL SIR CHARLES E. YATE, Bt., C.S.I., C.M.G., said he was not an expert, but he had been very interested in the question raised by Sir William Willcox as to whether any change had been made in the diet of the Indian sepoy to prevent the recurrence of scurvy. A curious instance had been given by Sir William Willcox of how the dietary of the British soldier in Mesopotamia brought on beri-beri, and the dietary of the Indian soldier brought on scurvy. The rationing of the Indian soldier had lately been taken over by the Government. Formerly the Indian soldiers bought their own rations, and much preferred to do so. He would like to know what had been done to ensure that the food of the Indian troops should be sufficiently rich in vitamins. With regard to the Chairman's remark as to the necessity, in his opinion, of increasing the area and quality of the pasture land, it had been the object of a good many people for some years to try and increase the amount of arable land in the country and to induce a larger number of people to take up work on the land, so as to improve the health of the population of England and grow more for ourselves. He believed the Chairman took the exactly opposite view. A committee was at present sitting to go into the whole question of agriculture. He hoped the Chairman would give evidence before that committee, and state the reasons for his opinions, and that the opposite side of the question would be brought out also, so that a rational solution could be reached. It would be interesting to see the arguments advanced on both sides.

MR. N. M. MUZUMDAR associated himself with the previous speakers in congratulating Colonel McCarrison on what was a most interesting and instructive paper on a subject that vitally concerned the health and wellbeing of the people.

Health and efficiency always went together, and nowhere perhaps in the world were human vitality, efficiency, and resistance to disease so low as in India, owing to insanitation and the ravages of pestilence and famine. He could only speak as a layman; and though it was perfectly true that money made a man, and no less did food, he was inclined to think that, apart from food, there were perhaps other factors that determined the physique, energy, vitality, and efficiency, of a people. Heredity was, after all, the accumulated result of ages; but even apart from heredity there was such a thing as the geographical factor. The Rajputs, for instance, whose physique and warlike qualities the reader of the paper was inclined to put down to their ideal food, had acquired those qualities for other reasons too. Perched on the Aravalli Mountains, stretching from the Ridge at Delhi to Mount Abu, the Rajputs had always been exposed to wave after wave of invasion from across the North-West and were always the defenders of India on the country's third line of defence, the first being the frontier ranges inhabited by the Pathans and the Dogras, and the second the desert of Thar. It was, therefore, their history, geographical surroundings, and tradition that determined their occupation and their qualities. On the other hand, the Bengali lived on a rich alluvial soil, the very fertility of which made for an easy life, with the result that Bengal had produced scholars, lawyers, artists, theologians, scientists, poets, and politicians. As against that, the people of the Gujerat had always been traders. At the exit of the two great cotton valleys, centred at the two great old ports of Surat and Broach, with cotton on one side and the sea on the other, they naturally became traders and did not perhaps need the food that the warriors of the North needed. So much, therefore, depended also on occupation. On the Malabar Coast, rice was the staple product on a soil water-logged by the waters that tumbled down the Ghats, and the sea and the creeks were an easy source of fish.

The point was that food itself was determined by the nature of the produce of the soil in which the people lived. Somebody said that caste played an important part in determining the nature of food. But it was curious that the Brahmins of India were not all vegetarians; they were certainly not in Bengal, nor in the North. It might, therefore, be said that food itself was determined by occupation, geographical surroundings and the conditions of climate. And it would be interesting to compare life tables and vital statistics to judge the value of foods, taking into account factors like the above. Incidentally, he would ask the reader of the paper, who had rightly laid great stress on the value of lactic products, if the vitamin content of milk and ghee, for instance, was lost in boiling or cooking. Also whether vegetable oils and vegetable "butter," used nowadays as substitutes, contained any vitamins.

Six or seven years ago he first came in contact with Colonel McCarrison in the matter of a Central Medical Research Institute scheme which Colonel McCarrison had much at heart. Such an Institute would have helped more fully to investigate problems of this kind, and though private benefactors were ready to help in its establishment, it took four years of negotiations with the Government of India to mature the scheme, and it almost materialised, when it was suddenly cut out for reasons of financial retrenchment. That one could perhaps understand. But what one could not understand was the very short-sighted policy of cutting out, even for such reasons, the very valuable work that Colonel McCarrison was doing, work that would have paid any country a thousand-fold, work immeasurable indeed in terms of mere money.

Dr. C. Muthu after referring to the invaluable service rendered to India by Dr. McCarrison's investigations, said the question of nutrition vitally concerned the physical efficiency of every nation. Faulty and deficient foods led to faulty nutrition which brought in its train inefficiency and ill-health. Civilisation meant tinned foods, refined foods, and stale foods—foods which were deficient in vitamins, proteins, and mineral elements, all of which were necessary for the growth and well-being of man. Take for instance, tuberculosis, which he (the speaker) had often shown to be a deficiency disease—deficiency of air, and light, and nutrition, causing lowered resistance, and opening the door to diseased conditions. How could they expect people living in the slums and fed chiefly on margarine, white bread and tea—foods deficient in vitamins which were so essential to growth and life—to be strong and vigorous ? So in India. Time was when Indian women in every household pounded their rice in large mortars and thus preserved all the germ, proteins and mineral found in the rice. But with the introduction of rice mills and the decorticating and polishing of rice, the majority of these essential proteins, etc., were lost and the nutritive value of rice as a food was considerably lowered. He was afraid that the introduction of polished rice in India would bring about lowered physique and degeneration of the Indian people. Poverty in India was bad enough. Living chiefly on rice, the staple food of millions in India, was bad enough. Rice diet, as Dr. McCarrison said, was poor in protein, vitamins and mineral elements, but it was worse when it was deprived of the little it had by milling and polishing. No wonder that the millions of rice eating Indians of the present day showed so little resistance to disease, and easily fell victims by tens of thousands to any epidemic that overtook them. Dr. McCarrison had proved himself the friend of India by pointing out the dangers of faulty and inefficient foods such as milled rice. It was nothing short of a calamity that India should be deprived of his services for his research work in India involved the welfare of millions of Indians. He (Dr. Muthu), hoped that the Indian Government would see its way to send Dr. McCarrison back to India to carry on his labour of love.

General Sir Edmund Barrow, G.C.B., G.C.S.I., in proposing a vote of thanks to Colonel McCarrison, said that although every one would go away with regret that they had been feeding on the wrong products for most of their lives, that would not lessen the thanks of the meeting to Colonel McCarrison for putting those present on the right lines.

Dr. J. Augustus Voelcker, M.A., in seconding the motion, said that Colonel McCarrison's address had been a very fitting supplement to a series of lectures which had been given before the Society not long ago by the distinguished Chairman of that meeting. Whether the people of England would follow the example of some of the better races, and take the food that they had been taking, was a question ; and he thought it would depend a good deal on the ladies—whether they would be inclined to carry their babies about for two and a half years and feed them for that period. But there were some directions, at all events, in which we could improve, and the Chairman, among others, had pointed out that not only were the vitamins of infinite use, but also that we ought to abstain from the use of antiseptics. He would not go into the various highly interesting agricultural questions that had been raised, but the lecturer had perhaps thrown a further light upon what he had always believed—that there was some virtue in the good, old-fashioned farmyard manure which did not exist in artificial manures.

Colonel McCarrison, in reply, said that his answer to the objection of certain American investigators to mixing fruit and carbo-hydrates would be that these articles of food were found combined in nature; they were, therefore, suitable for use together. With regard to the question as to the effect of heat on ghee, no doubt it destroyed a certain amount of vitamins, but only a certain amount. For instance, the vitamin C was destoyed by heat, but the vitamin B was not destroyed except by a very high degree of temperature. So far as he knew, the ration of the Indian soldier had been altered very considerably for the better of late years. In conclusion, he thanked the meeting most heartily for the way in which he had been received.

THE ARTIFICIAL SILK INDUSTRY IN FRANCE.

The strongly increased demand throughout the world, in recent years, for silk, artificial silk, and mixed silks (silk or artificial silk blended with woollen or cotton) has given for various reasons an immense stimulus to the artificial silk industry. The high price of raw silk, and the insistent demand among all classes for silk goods, more particularly the vogue of the silken hose, have encouraged the employment of the substitute for real silk. The output of artificial silks has no doubt already surpassed considerably in weight that of the pure silk industry. In the ten years 1913-1923 the total annual artificial silk production of the world has tripled from about eleven to about thirty-three thousand tons; but that of silk has remained stationary. The United States has been mainly responsible for the remarkable expansion of an industry which has had scarcely more than thirty years of effective existence, by raising her annual output over twentyfold—from 700 to 15,000 tons; but France and Belgium have each more than doubled theirs (from 1,500 to 3,200 tons); Italy has tripled hers, and now produces about 3,000 tons; and Germany, with 5,000 tons, has an output nearly 50 per cent. superior to her pre-war figure. American production, which is stated to be still making great strides forward, is expected to show within about a year the annual capacity of 20,000 tons.

Although France has notably increased her output, writes the Commercial Counsellor to H.M. Embassy in Paris, yet since the period of intense prosperity in her finished textiles and hosiery trades which set in towards the close of 1921, the principal users such as the silk fabric, hosiery and knitted goods centres (Lyons region, Troyes, Lille, Roubaix, Tourcoing, Mulhouse, and numerous smaller centres in the south) and the net and embroidery towns (Calais, Caudry, St. Quentin) have been forced to draw large supplies from foreign countries, especially from Belgium, owing to the total insufficiency of the home production. As a consequence of this sustained demand and the profitable nature of the industry in general, new capital both French and foreign is now being attracted for the foundation of artificial silk factories, and at the present time several enterprises are being or are about to be established in various parts of the country.

Two regions are being especially favoured. The Lyons area, the age-long centre of the pure silk industry, where already a considerable quantity of artificial silk is employed for mixing in piece-goods or for ties, ribbons and trimmings (St. Etienne, St. Chamond), already possesses several factories, and is naturally calculated to take a leading place in this industry, which bids fair soon to match and even to surpass the old in importance of output of finished goods in France. At the present time three-quarters of the factories in operation are situated in the Lyons or southern districts, and at least two very important factories in course of construction are situated in the suburbs of Lyons. North of Paris the great textile agglomeration, Lille-Roubaix-Tourcoing, is a great consumer of artificial silk for hosiery goods and mixed fabrics, whilst Troyes, the greatest single hosiery centre, acquires about 1,300-1,400 kilogrammes a day. Several factories are being planned for the northern region, *e.g.*, at Rouen, Valenciennes, Clairoy, etc.

As regards the relative output in the four standard systems (1) nitrocellulose, (2) copper-ammoniac, (3) viscose, and (4) acetate of cellulose, it would appear that the viscose process is employed for the vast bulk of the present output in France. The first-named, the original process used by the effective inventor (Chardonnet) of artificial silk at Besancon, is stated to be now in operation only at the Rennes works of the Société de la Soie Artificielle, whilst the second is being abandoned even at the one or two factories where it was followed. All the existing factories (save the one just cited) manufacture on the viscose system. The fourth method is, however, coming into favour, as it yields a more lustrous, supple, damp-resisting fibre than the others; it is being practised by the Usines du Rhône, and the great new Tubize concern in France will employ it.

WIND, WAVE AND SWELL ON THE NORTH ATLANTIC OCEAN.

A paper on " Wind, Wave and Swell on the North Atlantic Ocean " was read before the British Association, Section E (Geography), at Toronto, by Dr. Vaughan Cornish.

During a voyage from Southampton to Trinidad and back by R.M.S. *Oruba* the author took the period of the waves several times daily, from which their speed was calculated. The speed of the wind was ascertained by means of a Robinson anemometer, due allowance being made for the speed of ship and direction of wind.

The water is very deep from a short distance beyond Ushant, and free from strong currents as far as Barbados. The speed of the wind ranged from 13.9 to 23.6 statute miles per hour. That of the waves was in all cases less, the difference ranging from 1.0 mile an hour to a little more than 8.0 miles an hour. The latter is sufficient to keep a light flag flying. Anything less than 1 mile an hour is reckoned a calm. The difference was not proportional to the speed of the wind; nevertheless a relationship emerges when account is taken of the observations which were made simultaneously of the swell of the sea. When swell and wave ran precisely in the same direction (as sometimes occurred in the region of the Trade winds) and on one day when no swell was recorded, the speed of the wave was so nearly equal to that of the wind that the breeze blowing over the ridges was only equal to the " light air " which barely suffices to give steerage way to a fishing smack. Such a light air would be detected on land by drift of smoke, but would not move a wind-vane. Thus there was no longer a battle between wind and wave.

When the swell followed but crossed the wave the difference in speed of wind and wave was greater, and this difference increased rapidly when the crossing swelling swell was meeting, instead of following the wave. When the waves were much slower than the wind their height was always small, and sometimes their fronts were short and irregular. It was evident that the growth of waves in both length and height was much hindered by a crossing swell, and it can be safely inferred that the general absence of swell is a sufficient reason for the rapid rise of waves upon enclosed seas. When a wind comes on to blow in the direction of the ocean swell with a speed greater than that of the swell, the growth of large, steep, waves is very rapid (doubtless even more rapid than their growth from smooth water) but this occurrence is relatively rare in the North Atlantic.

The author found that the direction of the breaker out at sea was intermediate between that of wave and swell (the breaker being formed when they override) so that the practice of observing the direction of " the curl on the water " as a method of determining the direction of the wind gives an erroneous result whenever there is a crossing swell, which is the usual condition upon the oceans. The general run of the waves, on the contrary, shows the direction of the wind reliably.

STATE AID TO COTTON AND TOBACCO CULTIVATION IN SPAIN.

From the annual report of the Commercial Secretary to H.M. Embassy at Madrid it appears that the cultivation of cotton in the province of Granada has been commenced under Government protection, and has given very successful results. In June, 1923, the Government appointed a Commission, consisting of representatives of various Spanish industrial and agricultural bodies, to study the possibilities of cotton cultivation in Spain. This was followed by a Government grant of 10 millions of pesetas, to be spread over a period of five years. Further legislation prohibited importation, circulation, and sowing of cotton seed, unless it had been examined by the State Cotton Commission and found to be free from disease and suited to the requirements of the Spanish cotton-growing districts. The clearing of consignments imported was restricted to the customs houses of Cadiz and Barcelona. Should this Government intervention result in the effective establishment of cotton cultivation, it would naturally be of great value, not only to Spain herself, but to other consuming countries, as the visible supplies of cotton are reported to be decreasing year by year. Experiments which have been carried out appear to show that the conditions of climate and soil are such as to inspire optimism, and it should not be forgotten that during the War of Secession, when supplies of cotton from the United States were cut off, considerable quantities were actually produced in Spain.

In the same Report the Commercial Secretary states that the Spanish Government have authorised the State Tobacco Monopoly to make a trial of cultivation of tobacco in Spain, to the total number of 12,000,000 plants. These trials will be superintended by a commission, who will supply seeds at the price of 10 cents per gramme. Each cultivator will be required to sow 2,000 plants as a minimum. Prices payable at warehouse for the dry leaf will vary from 2.50 pesetas to 1 peseta per kilogramme, according to quality. In Valencia and throughout the Levant district the cultivation of tobacco should give very good returns as, apart from the manuring of the soil before planting, the cultivation is a comparatively simple matter.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock, unless otherwise announced :—

JANUARY 21.—MRS. GRAYDON-STANNUS, " Irish Glass, Old and New." SIR HERBERT JACKSON, K.B.E., F.R.S., will preside.

JANUARY 28.—CHARLES A. BAKER, Assistant Engineer, London County Council, " The Electrical Equipment of the London County Hall." SIR GEORGE HUME will preside.

FEBRUARY 4.—SIR ERNEST RUTHERFORD, M.A., D.SC., F.R.S., *Trueman Wood Lecture,* " The Stability of Atoms."

FEBRUARY 11 (at 4.30 p.m.).—SIR J. FORTESCUE FLANNERY, Bt., Past-President of the Institute of Marine Engineers, " The Diesel Engine in Navigation." LORD BEARSTED, LL.D., will preside.

FEBRUARY 18.—J. S. OWENS, M.D., Assoc.M.Inst.C.E., F.G.S., Superintendent Advisory Committee on Atmospheric Pollution, Air Ministry, Meteorological Office, " Modern Atmospheric Conditions."

FEBRUARY 25.—SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., " The Power of Internal Combustion Engines for Motor Cars."

MARCH 4.—PROFESSOR W. E. S. TURNER, O.B.E., D.Sc., F.Inst.P., Department of Glass Technology, University of Sheffield, " The Modern Production of Sheet-Glass."

MARCH 11.—EMILE CAMMAERTS, " The Restoration of Public Buildings in Belgium."

MARCH 18.—CLAUDE N. FRIESE-GREENE, " Colour Cinematography."

MARCH 25.—HENRY G. DOWLING, " Wall-papers."

Dates to be hereafter announced :—

MAJOR-GENERAL SIR WILLIAM SEFTON BRANCKER, K.C.B., Director of Civil Aviation, Air Ministry, " Commercial Aviation."

CEDRIC CHIVERS, " Bookbinding."

C. R. PEERS, C.B.E., F.S.A., Chief Inspector of Ancient Monuments and Historic Buildings. (Subject to be announced later.)

LIEUT.-COLONEL ANDREW BALFOUR, C.B., C.M.G., M.D. (Edin.), B.Sc. D.P.H., F.R.C.P.E., " The Trend of Modern Hygiene."

DAVID GREENHILL, " Colour Printing."

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock :—

JANUARY 9.—LIEUT.-COLONEL SIR DAVID PRAIN, I.M.S., C.M.G., C.I.E., M.A., M.B., LL.D., F.R.S.E., F.R.S., *Sir George Birdwood Memorial Lecture,* " Government Botanical Gardens." HON. VICARY GIBBS will preside.

FEBRUARY 6.—J. T. MARTEN, M.A., I.C.S., " The Indian Census." SIR EDWARD ALBERT GAIT, K.C.S.I., C.I.E., will preside.

MARCH 6.—SIR HENRY SHARP, C.S.I., C.I.E., M.A., " The Development of Indian Universities."

MAY 8.—SIR GILBERT T. WALKER, C.S.I., M.A., F.R.A.S., Sc.D., Ph.D., F.R.S., " Indian Meteorology."

JUNE 12.—BRIGADIER-GENERAL SIR PERCY M. SYKES, K.C.I.E., C.B., C.M.G., " The Heart of Asia and the Roof of the World."

Date to be hereafter announced :—

SIR ALFRED CHATTERTON, C.I.E., Assoc.M.Inst.C.E., "The Industries of the Mysore State."

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons, at 4.30 o'clock, unless otherwise announced :—

JANUARY 27.—WALTER RONALD DUNLOP (late Professor of Economics, Imperial College of Tropical Agriculture), " Economic Research in Tropical Development."

FEBRUARY 24.—R. H. BRACKENBURY, Member of the Empire Cotton Growing Corporation Mechanical Transport Sub-Committee, " Transport in Tropical Africa."

Dates to be hereafter announced :—

HON. W. G. A. ORMSBY-GORE, M.P., Under Secretary of State for the Colonies. (Subject to be announced later.)

LORD BLYTH, " Penny Postage and Postal Communications Generally."

DOMINIONS AND COLONIES AND INDIAN SECTIONS. (JOINT MEETING).

Date to be hereafter announced :—

LORD STEVENSON, G.C.M.G. (Chairman, Standing Committee of British Empire Exhibition), " The British Empire Exhibition." SIR CHARLES CAMPBELL McLEOD (Chairman of the Finance Committee of the Exhibition) will preside.

CANTOR LECTURES:

Monday evenings, at 8 o'clock :—

V. E. PULLEN, Director, Radiological Research Department, Woolwich, " Radiological Research—A History." Three Lectures. January 19, 26, February 2.

LECTURE I.—Natural Philosophy. The fascination of speculative philosophy. The border line between science and philosophy. Early natural philosophy. Development of theory. Discovery of X-rays. Controversy as to their nature. Modern theory concerning X-rays. Relation to modern atomic theory.

LECTURE II.—Early apparatus. Early X-ray generators. Early vacuum tubes. X-ray tubes. Development of electrical generators. Development of X-ray tubes. The X-ray spectrometer. Measuring apparatus. Lines of modern radiological research.

LECTURE III.—Early applications of X-rays. Development of medical uses. Modern applications. Physiological dangers. Necessity for protection.

WALTER ROSENHAIN, B.A., B.C.E., D.Sc., F.R.S., Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory, " The Inner Structure of Alloys." Three Lectures. February 16, 23, March 2.

HOWARD LECTURES.

Monday evenings, at 8 o'clock :—

PROFESSOR JOHN SAMUEL STRAFFORD BRAME, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, "Motor Fuels." Three Lectures. April 20, 27, May 4.

Dr. Mann Juvenile Lectures.

Wednesday afternoons, at 3 o'clock:—

Lieut.-Colonel E. H. Richardson. Two Lectures. January 7 and 14, 1925.

Lecture I.—January 7.—"Dogs in War."

Lecture II.—January 14.—"Dogs in Peace."

(Special tickets are required for the Dr. Mann Juvenile Lectures.)

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

Monday, January 5..Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, Piccadilly, W. 8 p.m. Mr. W. Irwin, "An early Chapter in the Benzol Industry."

Transport, Institute of, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C. 5.30 p.m. Brig-Gen. H. O. Mance, "Recent Developments in the Industrial Elements of Transportation."

Tuesday, January 6..Petroleum Technologists, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 5.30 p.m. Mr. J. B. Hoblyn, "The Behaviour of Lubricating Oils Under Oxidising Conditions."

Marine Engineers, Institute of, 85, The Minories, E. 6.30 p.m. Mr. C. W. Wright, "The Measurement of Oil in Tanks."

Metals, Institute of (Local Section), Chamber of Commerce, New Street, Birmingham. 7 p.m. Mr. T. H. Gant, "Cobalt, Its Production and Some of its Uses."

Anthropological Institute, 50, Great Russell Street, W.C. 8 p.m.

Royal Institution, Albemarle Street, W. 3 p.m. (Juvenile Lecture). Mr. F. B. Browne, "The Habits of the Water Beetle."

Wednesday, January 7..Engineers, Junior Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 7.30 p.m. Inaugural Address by the President, Dr. A. Russell.

Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. (Wireless Section). Prof. E. Mallett and Mr. A. D. Blumlein, "A New Method of High-Frequency Measurement."

Thursday, January 8..Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. Mr. H. W. Taylor, "Three-Wire Direct-Current Distribution Networks. Some Comparison in Cost and Operation."

(Sub-Centre), University College, Dundee. 7.30 p.m. Mr. F. J. Lawson, "Telephonic Cable Practice."

Child Study Society, 90, Buckingham Palace Road, S.W. 3 p.m. Prof. E. W. Macbride, "The Evidence for the Existence of Environmental Influence on the Course of Heredity."

Historical Society, 22, Russell Square, W.C. 5 p.m. Mr. G. H. White, "Financial Administration under Henry 1st."

Mechanical Engineers, Institution of (West of Scotland Branch), at the Royal Technical College, Glasgow. 7.30 p.m. Mr. J. A. Legros, "Traction Across Rough and Roadless Country."

(South Wales Branch) South Wales Institute of Engineers, Cardiff. 6 p.m. Annual Meeting.

(Graduates' Section, North Western Branch), at the Engineers' Club, Albert Square, Manchester. 7.15 p.m. Mr. E. H. Lewis, "The Reduction of Factory Costs."

Royal Institution, Albemarle Street, W. 3 p.m. (Juvenile Lecture). Mr. F. B. Browne, "The Habits of Insects and the Work of Man."

Friday, January 9..London Society, at the Royal Society of Arts, John Street, Adelphi, W.C. 8 p.m. Mr. A. C. Bossom, "The Traffic Problem of London; Some Thoughts on its Solution."

Philological Society, University College, Gower Street, W.C. 8 p.m. Miss Beatrice Saxon Snell, "Anglo-French Building Terms."

Astronomical Society, Burlington House, Piccadilly, W. 5 p.m.

Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W. 6 p.m.

Mechanical Engineers, Institution of (North Western Branch), The University, Liverpool. 7.30 p.m. Mr. L. A. Legros, "Traction Across Rough and Roadless Country."

(Yorkshire Branch), Philosophical Hall, Park Row, Leeds. 7.30 p.m. Mr. H. W. Bannister, "The Scientific Treatment of Boiler Feed-Water."

(Informal Meeting), Storey's Gate, Westminster, S.W. 7 p.m. Discussion on "The Maintenance of High-Compression Oil-Engines."

Metals, Institute of (Local Section), at the University, St. George's Square, Sheffield. 7.30 p.m. Mr. A. H. Mundey, "Die Casting."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. A. Keighley, "Colour and Sunshine, Some Mountain Villages of Southern France."

Aeronautical Engineers, Institution of, at the Engineers' Club, Coventry Street, W.1. 6.30 p.m. Mr. R. J. Parrott, "The History and Evolution of the Avro Training Machine."

Saturday, January 10..Metals, Institute of (London Section), at the Institute of Marine Engineers, 85, The Minories, E. 7.30 p.m. Dr. R. H. Greaves, "Extensometers."

JOURNAL OF THE ROYAL SOCIETY OF ARTS

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FRIDAY, JANUARY 9, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 14TH, at 3 p.m. (Dr. Mann Juvenile Lecture.) LIEUT.-COLONEL E. H. RICHARDSON, "Dogs in Peace." (Lecture II.) LORD ASKWITH, K.C.B., K.C., D.C.L., will preside. Tea and coffee will be served in the Library after the lecture.

All the tickets for these lectures have now been issued.

BINDING COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their annual volumes of the *Journal*, cloth covers can be supplied, post free, for 2*s*. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

FIFTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 10TH, 1924.

MR. THOMAS J. IVE (Vice-President, Anglo-Colombian Chamber of Commerce), in the Chair.

THE CHAIRMAN said that Mr. Norman Thomson had written a number of books on Colombia, one having been published under the authority of the Government, and another, after publication, having been translated into Spanish in Colombia by the Government with the consent of the author. A third publication dealt with the political issues bearing on the Panama Canal question. It might also be mentioned that Mr. Thomson had given evidence before the British Government Select Committee which was appointed several years ago to report upon the Putumayo atrocities. He had advocated the settlement by arbitration of the disputed regions as the only effective way of stopping the atrocities, and that point of view had been generally endorsed by the Committee in its report. A cablegram had been received, signed by His Excellency the President of Colombia, by the Colombian Bureau of Information on the previous Friday, reading as follows: " Your letter of the 17th October received. Please present distinguished lecturer, Mr. Thomson, my cordial sympathy, hearty gratefulness and best wishes for the success of his generous effort."

The paper read was:—

COLOMBIA AS A FIELD FOR DEVELOPMENT.

By NORMAN THOMSON.

Developments in this Republic during the last fifteen years, combined with the present economic position of the country and the known possibilities of its undeveloped resources, are such as to arrest and call for closer attention. It is a country with a future that is of the greatest promise, and with a past history that, broadly, should be understood. When a colony of Spain Colombia was the richest and the most developed country in South America, but from the year 1810, when independence was won from Spain, until the year 1910, when the political life of the country was reconstructed, the great promise expected from its fuller development was never fulfilled. Instead, the glamour of its wealth receded more or less into the shadow of legend, and it is only within recent years that it has again emerged as a land of definite promise.

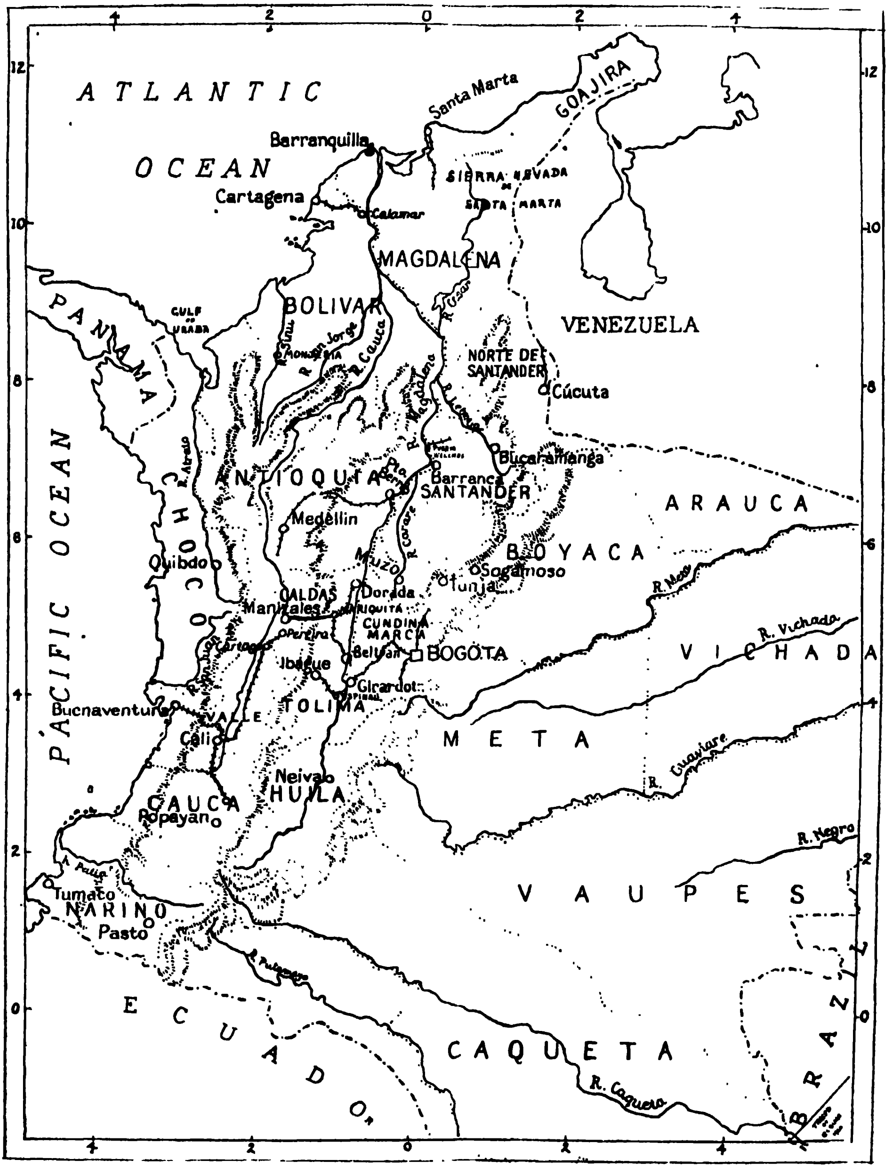
During the long era when development was retarded by successive revolutions that devastated the country and made necessary a compromise of its foreign debt with the foreign bond-holders, as well as by lack of adequate transport facilities, attempts to develop some of the country's resources were undertaken chiefly with the aid of British capital. Many of these attempts were successful; others were not, and they were not infrequently the cause of long-protracted and embittered disputes between the concessionaires and the Government. The effect in general was to provoke unfavourable comment abroad to the economic disadvantage of the country as a whole. The cause of failure of enterprises which had acquired or planned to secure certain interests in the country was mainly due to two reasons. Many of them were mining ventures which were founded on an irresponsible conception as to the commercial accessibility of the country's wealth, and failure was due either to inadequate investigation of the mine to be worked, to the purchase of unsuitable machinery, to mismanagement, to the absence or shortage of water supplies, labour and timber, or to insufficient financial reserves. It was not uncommon to find machinery rotting on many abandoned mines, and, owing to the unconsidered difficulty of transportation, on the banks of navigable rivers. The second reason was that concessions and monopolies freely granted by the Government, in the absence of other means to promote the development of the country, often embodied terms that were unfavourable to the country, and they were resented by the Colombian people. Internal dissension was the result. For such reasons confidence in the country on the part of foreign capital, which was practically all British, was continuously weakened.

At the present time there are unmistakable signs that this depressed outlook in respect of Colombia as a possible and profitable field for development has given place to an awakened and livelier interest in the admitted possibilities awaiting its fuller commercial exploration and exploitation. In this respect the present position of the country cannot better be reviewed briefly than by a repetition of well-known facts. In 1910, when Colombia first began to attract responsible foreign interests to any extent, the political life of the country underwent a substantial change, economical principles being substituted for partisan political principles, and with this reconstruction a more democratic form of public administration was established. With the general knowledge and in the confirmed belief that the community of interests common to a nation as a whole makes for better conditions, the Colombian people set themselves to work on the development of various plans for their better prosperity, and in the short period of less than fifteen years their advance has been extraordinary, having regard to the many preceding years of commercial retrogression or stagnation.

Since 1905 the nation has regularly met its Foreign Debt and as the amount of the consolidated external debt is now only about 1¼ million pounds, the whole debt should be redeemed before long. The total foreign debt of the country, which is nearly all held in England, is £4,199,559, and the total internal debt approximately £3,600,000. The entire foreign debt only reaches the small total of 12s. 9d. *per capita*, the smallest in South America, and the internal debt amounts to less. The external debt amounts to less than the product of the national revenues for one year, and taxation is lower than in any other State in Latin America. In 1923 the Colombian Congress approved laws establishing a gold standard for Colombian money and a National Bank of Issue capitalised at $10,000,000. The amount paid up exceeds $7,000,000 and the first annual report has been issued. The banking industry of the country has increased from 14 banks with a total capital of $6,000,000, or about £1,200,000 at par in 1913, to 73 banks with a paid-up capital of $30,000,000, and with reserves of $7,000,000, a total capital of about £7,400,000 in the present year. This shows an increase in 10 years of more than 600 per cent., and it includes seven foreign banks with a capital of nearly 1½ million pounds. In 1910 coffee exports amounted roughly to 34 million kilos, and in 1923 to 123 million kilos. This article fetches the highest price in New York, where the bulk of the shipments go, and in the extent of its production Colombia stands next to Brazil. Its gold production exceeds that of any other State in South America, and in the matter of platinum exports these are now the largest of any country in the world, amounting in 1910 to 13,664 oz., and in 1923 to 43,100 oz. The first four months of the present year show a production of 20,102 oz.

A few remaining facts that may be briefly recorded, not as indicating the economic stature of this country, but as signs of the progress that the country is now making, a country probably less developed in proportion to its possibilities, extent and population than any State in Latin America, are the following:—During the last few years over sixty hydro-electrical power stations have been installed in the country and work on other similar undertakings is now in progress. In the last thirteen years its foreign trade has been trebled, and its banana production makes it the second largest exporting country of that fruit in the world. The discovery of oil by foreign oil organisations is of comparatively recent date, but it is certain to play a leading part in the future of this nation, for Colombia is authoritatively declared to possess the most promising oil-region in the world. Colombia is also now in a position to establish a frozen meat market with Europe. Cotton crops have been more than doubled since 1915, and the cotton produced manufactured into fabrics for the home market. One of its great fertile valleys, which is rather larger than British Honduras, the Cauca Valley, was called by the great Humboldt the "Paradise of the World," and has a line of rail extending nearly its whole length of 200 miles. A vast coal-field has been brought into rail communication with the Pacific Ocean, and the country's population of some 6½ millions is steadily increasing. Its manufacturing industries continue to be increased and extended. Its railway mileage has been nearly doubled since 1910 and many new lines and extensions of existing lines are under construction. Aerial ropeways, which offer great promise in the development of this land of high altitudes alternating with great valleys, are being extended. Important long-distance motor roads are now under construction. The "Dique," a natural canal connecting the sea-port of Cartagena with the Magdalena River, navigable in the Spanish colonial days for large boats, is being deepened to enable the largest river boats to reach the sea wharves, and the unnavigable mouth of the Magdalena River is to be opened up under a percentage contract with an American firm. These two undertakings, when completed, will respectively make Cartagena a river port and Baranquilla a seaport.

Occupying some 450,000 square miles of the South American Continent, on its north-western corner, and possessing the economic advantage of two oceans for its sea-board, Colombia is divided longitudinally into three main divisions by three lofty mountain ranges, known as the Western, the Central and the Eastern Cordilleras respectively. Another group, in the north-eastern section, is known as the Sierra Nevada Range. By reason of these physical features, with their economic advantages and disadvantages, every variety of climate is encountered, ranging from the torrid coast-regions and the cooler temperature of the more elevated valleys, to the temperate table-lands that



COLOMBIA.

are mountain continents, and beyond to the regions of perpetual snow. Here in these varying mountain altitudes, low-lying valleys, extensive plains and level uplands, the physical world may be said to be represented in all its variations, and their resources to embrace the world's resources.

The river system of the country is extensive and numbers of the larger waterways are navigable for considerable distances. The largest, the Magdalena River, flows between the Eastern and Central Cordilleras. It is the main artery of commerce, being used for navigation on the Lower River, which is separated from the Upper River by a series of rapids, to the extent of about 600 miles, and on the Upper River of about 300 miles. A tributary, the Cauca River, some 200 miles from the mouth of the Magdalena River, is the second largest river in the country and has an important tributary, the Nechi River. Other navigable tributaries of the Magdalena River include the Lebrija, the Cesar, and the Sogamosa. Two great valleys are formed by the Magdalena and its principal tributary. The Cauca Valley stands at a mean elevation ranging from 3,000 feet to 3,500 feet. The Sinu River lies to the west of the Magdalena River and beyond it, flowing into the Bay of Uraba' on the Gulf of Darien near the Panama boundary, is the Atrato River. The Patia is the largest river on the Pacific, into which also flows the San Juan River. At their source the Atrato and San Juan Rivers are only separated by a short divide called the Isthmus of San Pablo. Here and elsewhere on the upper reaches of the Atrato River the possibility of constructing an inter-oceanic waterway has long been a subject of speculation and expectation. In 1913 the United States Government offered Colombia first $2,000,000 and later $5,000,000 for an option to build an Atrato Canal, and it may well be that at some future date in the history of Colombia some commercial use may be put by Colombia to the natural links that exist between the two oceans.

The two rivers, the Putumayo and the Caqueta, tributaries respectively of the Amazon and the Orinoco, find a navigable outlet outside Colombian territory through these great trunk waterways. The country's waterways on which navigation is practicable cover about 2,500 miles, oil as well as steam now being used, but owing to protracted seasons of drought navigation is not always continuous throughout the year, even on the great Magdalena waterway. This factor seriously impedes the trade of the country, and, therefore, important as they are to its economic prosperity as channels of commerce, they are in themselves inadequate, as in the past, to meet the demands of the future. Moreover, rivers run in valleys and not over mountain slopes.

Railway construction and development is, therefore, Colombia's primary need. It is the key to her economic progress, the foundations on which alone the great and boundless resources of the interior can be developed within any measureable extent of their promise. Formerly, construction was left to private enterprise, but Colombia has had a discouraging experience during the past 50 years with the various scattered activities of foreign enterprise. Some of the companies formed to carry out the concession discontinued work after a few years, and others never commenced serious operations. On these schemes varying sums of State money have been spent, the cost to the Government in connexion with the construction of the Pacific Line for 40 miles of track laid, and covering a period of some 30 years, amounting to somewhere about one million pounds, or at the rate of about £25,000 per mile built. Moreover, when knowledge of the physical and geological features of the country to be traversed by a new line was insufficient to provide the data necessary before construction could be satisfactorily undertaken, several lines, which also cost the Government a great deal of money, were constructed that were badly located and should never have been built. Projects are now in hand for new construction which will make one or two of these lines of little value.

At the present time the railways of the country are owned respectively by the National Government, the Governments of the Departments or States and private enterprise. New constructional work is now largely carried out by the National Government, and by the Departments concerned. The National Government allows a Department a fixed subsidy for each kilometre built, the subsidy being financed by internal-loan bonds, and recent national legislation has authorised various departments to raise internal or foreign loans to finance new lines, the department undertaking construction itself or entering into negotiations for the work. The National Government pays the subsidy on completion of each kilometre. The amounts of these subsidies vary according to the construction to be done. The Department then proceeds to raise its loan, one recent authorisation by the Department of Caldas for a loan of £1,000,000 guaranteeing (*a*) the Railway of Caldas with all its dependencies, (*b*) the lines now constructed or to be constructed, and (*c*) the Tobacco Revenue. The net receipts of the exploitation of the extension of the railway line, together with any other railway revenues whatever their source might be, were to be applied to interest and the amortisation of capital.

Other recent national legislation indicates the present policy of the Government in respect of railway construction and development. In 1922 the Government passed a law authorising the loan of $100,000,000 mainly for railways. The security was to be (*a*) a mortgage on all or part of the railways built, or to be built, to which the capital of the loan was to be devoted, (*b*) a hypothetical lien on the net receipts accruing from the operation of the lines in question or some of them, and (*c*) a sinking fund formed by the $20,000,000 due from the United States Government under the terms of the Panama Canal Treaty. Departments were to be entitled to take part in the financial operations, and contracts for construction were to be subject to the proviso that the constructors contributed a share not less than one-half of the actual building, the Government undertaking to co-operate up to the other half. The builder was not to be allowed any control of management after construction and he was not to be entitled to any public lands or other concessions. Again, an invitation to foreign capital to undertake the construction and equipment of a railway specified that the contractor should furnish all the necessary funds for the construction and equipment, including payment for the land, by subscribing the bonds to be issued by the Government as the work proceeded. These bonds were to bear interest at 8 per cent., with 2 per cent. for sinking fund, and they were redeemable when and how most convenient. The Government on its part undertook to grant to the contractor the administration of the railway for an agreed period and for this service 5 per cent. on the gross production of the exploitation was to be paid until completion. Subsequently a new arrangement was to be made on the net product of operation as payment for administration. The Government was to pay the contractor a commission up to 12 per cent. for services rendered in the construction and administration of the railway at amounts varying from 18,000 dollars per kilometre to 48,000 dollars, according to the section of the line to be constructed.

In Colombia opinion is divided as to the wisdom of the Government's policy in embarking upon railway construction other than by means of foreign capital, on the ground that the money should be used in the country for national, industrial and agricultural development, but in these inland and precipitous regions the percentage contract is probably no more economical than construction by the State. On the other hand, on the facts, the physical conditions of the country are such as would appear to debar companies from embarking to any extent, as in the past, upon construction unless on favourable terms. In the meantime, the country needs railways urgently in order to open up the productive regions of the interior. The problem of financing the country's extensive undertakings and plans is, therefore, immediate, and without the aid of foreign capital and enterprise it is difficult to foresee any rapidity of development. In Colombia, however, we now find evidence to show that there has been an economic awakening and that its possibilities are such as to be more easily understood. If, therefore, every inducement could be given by the Government to private enterprise to expedite the extension of the country's railway system, and if private enterprise could be induced to regard this South American Republic and its resources as one of the great potential possibilities of that continent, it may well be that new markets would be found for British manufactures, a new source of income established, and with the certain and ultimate development of Colombia an opportunity afforded for an increasing trade.

As the greater number of Colombian railways are now owned either by the State or the Departments and as the need for finance is so imperative, it might be that a new channel of constructive thought could be applied to the railway system of the country and to its new lines and extensions to existing lines. One such line of thought has occurred to me, and that is the policy of joint ownership and management by the State and private enterprise. This was a policy I first advocated some sixteen years ago in connexion with development proposals within the Empire. It might be adopted in the case of Colombia with great advantage to the economic development of the country, and it suggests a possible solution of her transportation problem. A private company, on formation, would be required to provide the capital, and the extension would then be regarded as one single system owned jointly by the Government or Department and the company. The share of the new capital would be arrived at by determining its proportionate value to the capital value of the original main line. The National Government or Department might reserve the right to purchase the cash shares of the company on agreed terms and at the expiration of an agreed period, and during construction of new main lines a guarantee of a small rate of interest on the capital outlay by the National Government or Department should be allowed in order to attract foreign capital. Since the war a large number of proposals embodying this general policy have been brought forward and discussed in relation to Imperial projects. The plan, with certain modifications, has been in force in Belgium for very many years in connexion with the light railway system of that country. In Germany, in more recent years, the provinces and municipalities and the large industrial organisations interested in the particular public utility company to be formed jointly subscribe. The company, as in other cases, would be subject to Colombian law and the jurisdiction of the Colombian courts.

The largest and most important railway project in Colombia is the construction of the Pacific line, which will provide, via Ibagué, direct rail communication between Bogota, the Colombian capital, and Buenaventura, the chief Pacific port, a distance of 480 miles. Starting from Buenaventura and passing through Cali, construction extends as far as Cartago north of the point where it will branch off to Ibagué, its eastern terminus. It has been extended in the south from Cali, the junction to the north and south, to within 15 miles of Popayan, the distance to this city from the coast being 125 miles and to Cartago 207 miles. On the Bogota route 147 miles remain to be completed to reach Ibagué. Another branch line on which work has been started runs towards Santander lying east of the Popayan branch line. The Pacific line, therefore, now runs practically the entire length of the Cauca Valley or from close to Popayan to Cartago, a distance of about 183 miles.

At Ibagué, the terminus of the Pacific line on its completion, the Tolima Railway forms the next link to Bogota, running from Ibagué to Flandes opposite Girardot on the Magdalena River, and on completion of a bridge across this river (a contract for which was placed with a British firm) communication will be completed to Bogota by the Girardot Railway running to Facatativa, on the edge of the Bogota table-land, and from thence by the Sabana Railway to the capital. When the chain has been completed between Bogota and the Port of Buenaventura it is estimated that freight charges will amount to about one-half of what it now costs to carry freight to Barranquilla on the Atlantic. The Pacific Line was bought in 1919 by the Government.

The line will be eventually connected with the Antioquian railway system with the object of forming an important trunk line which will connect the

Atlantic and Pacific ports. At Cartago it is connected with the Caldas Railway now under construction from Puerto Caldas, on the Cauca River near to Cartago, to Manizales further north. More than one-half of this 63-mile line has been completed, and plans call for its extension from a point not far south of Manizales to connect, north of that town, with the Amaga Railway running from Medellin through the important Amaga coal-fields in the direction of the Cauca River. Some 52 miles of this last-named line have been constructed and when finished and joined with the completed Caldas Railway extension, Medellin will be brought into rail communication with the Pacific coast. From Medellin the Antioquia Railway, which has doubled its traffic every five years, runs in two sections, divided by an uncompleted tunnel, to the Magdalena River. The distance from this river to Buenaventura is about 480 miles, but a projected line from Medellin, via Monteria, to Cartagena will give Medellin a direct rail outlet to the Atlantic. On completion, therefore, of this projected line, together with the construction of the extensions to the Amaga and Caldas Railways, Cartagena on the Atlantic will be brought into rail communication with Buenaventura on the Pacific and with Popayan in the far south.

Various extensions of existing lines are now in course of construction, and others, including new lines, will shortly be undertaken. The Northern Railway is being extended from Bogota to Quiquinquira and the Southern Railway to Fusugasuga. A new line under construction is the Tolima-Huila-Caqueta Railway, which will connect Espinal on the Tolima Railway with the city of Neiva, and subsequently it is proposed to extend it to the Caqueta. Work on the uncompleted Puerto Wilches-Bucaramanga line is being actively pressed forward. The Cucuta Railway which connects the town of that name with the Zulia River crossing the Colombia-Venezuela border is to be extended to the Magdalena River and the Sabana Railway is also to be carried to that river from Facatativa, which town it connects with Bogota. The Tumaco-Pasto Railway will connect the Southern Pacific Port with the city of Pasto, and the Carrare Railway is intended to connect Bogota with the Magdalena River through the Carrare district. Varying sums of money have been allotted from the Panama Indemnity payment to these and other railways for their construction or extension, and it may be mentioned that the law of last year authorising a loan of 100,000,000 dollars was for the purpose of carrying out the Government's plans for an extended railway system in the country. The proposal to establish rail communication between Bogota and the Atlantic, which was one of the projected plans of the Government when authorising the loan, appears to have been postponed. At present Bogota is reached from the Atlantic by the Lower Magdalena River, the El Dorada Railway, the Upper Magdalena River and the Girardot and Sabana Railways. A recent development in Colombia is the introduction of the aerial ropeway for the transportation of merchandise. One has been completed between Manizales and Mariquita on the Dorada Extension Railway, a distance of 45 miles. Other ropeways are now under construction, and it is certain that with their extension the economic development of the country will be carried an important step forward.

The problem that may now be considered is, what security in the form of its resources does Colombia offer to foreign capital and enterprise, if such should be enlisted to a considerable extent in promoting the development of the country? It must first clearly be borne in mind that Colombia, though old in the commercial history of Western civilisation, has not yet emerged from the early stage of development. Fuller developments must primarily depend, as in all countries, upon the facilities for bringing its productions to the markets of the world, and at the same time the manufactured products from outside to assist in that development. In its agricultural and mineral development Colombia has experienced this signal handicap to an exceptional extent, owing to the physical features of the country. In the case of Colombia's agricultural products, which are as varied as its climate, they have to find a way to the coast, and this is costly, slow, and sometimes harmful to their commercial value. For example, wheat for milling into flour at the coast can be imported more cheaply than it can be brought from the Bogota region down the Magdalena River. The force of this point applies with equal, if not greater strength, to coffee exports. Coffee is the principal export of Colombia, and its production affects the economic conditions of the entire country. If the crop is good prosperity prevails. The volume of the import trade depends upon it, for the purchasing power of the people is increased. The financial condition of the Government is regulated by it, for the greater part of the national revenues is derived from the import duties. Industrial development, and the local Governments, through their tax returns, are also affected, equally with the production of more coffee and other agricultural products. In all the circumstances of its production, it says much for the coffee of Colombia that it is able to compete in the world markets with the coffee of other countries, where production is not similarly handicapped.

Coffee is produced in most of the Departments, but at present principally in Antioquia, Cundinamarca, Santander Norte and Santander Sur. Its cultivation is chiefly confined to districts accessible to settlements or villages, but widely extending mountain slopes, more remotely removed from populated districts and still in a state of nature, are eminently fitted for its cultivation. Land in general is obtainable at a nominal cost, and labour, on these upland slopes, is sufficiently abundant, industrious and intelligent. Most of the plantations are small, the planter taking care of his farm with the assistance of his family, and a little outside help during the harvesting season. A large part of the coffee produced is sold by the small grower to the local merchant, who, as a rule, advances the money for harvesting the crop. It is seldom re-cleaned and graded, and accordingly there is here some scope for improvement. Some planters have a working arrangement with the owner of the land, by which he receives part of the crop, but larger plantations, varying from 100,000 to 1,000,000 bushes, have also been established.

From Antioquia coffee reaches the coast by the Antioquia Railway, and the Magdalena River, by distant Manizales, and the new ropeway to the same river, and by Cali on the Pacific Railway to the Pacific coast. The Cundinamarca coffee finds its way by three railways, and two transhipments on the Magdalena River, but on completion of the Pacific Railway a direct outlet to the coast will be effected by that route, as well as from Tolima, which is developing its coffee production. From Caldas, pack mules carry the coffee over the mountains to the ropeway at Manizales, and Santander Sur sends its coffee by way of the Lebrija, a tributary of the Magdalena River, and Santander Norte through Lake Maracaibo in Venezuelan territory. It will be seen from these general details that the recently constructed ropeway from Manizales to Mariquita is an important economic asset to the country, and with the completion of the railway construction now in progress coffee production cannot fail to be considerably extended, and the improved conditions under which it will be brought to outside markets should add to its commercial value. The best of all the coffee producing districts is probably in the Quindio valley, and this will be opened up on the extension of the Pacific Railway towards Ibagué.

The agricultural future of Colombia should not be dependent wholly, or even in large part, upon the coffee industry, for, with its varied climate, its range of cultural extension is of the widest. Cacao, which is at present little produced in Colombia for export, though of high market value, is found in nearly every region of Colombia, and where irrigation, which is often necessary, has been introduced, considerable success has marked its cultivation. Tobacco cultivation is as yet in its infancy, and its production is widely carried on by more or less primitive methods. The famous " yucca " or "manioc " offers interesting possibilities for the manufacture of starch and industrial alcohol, and the castor oil plant, growing wild throughout the country, could be made profitable by its systematic cultivation on a large scale. Coconut cultivation could be widely extended, for the coast region from Cartagena to the Gulf of Uraba is specially suited for this product. Cotton is the most important agricultural product of the Magdalena Valley near Barranquilla, and is grown on small farms by individual owners or renters. At present it is planted without any real preparation of the soil, and weeds are chopped out with the "machete." Replanting is not necessary for five years. It grows everywhere in the country with wonderful luxuriance, but the Cauca Valley probably offers the most promising possibilities for this cultivation. The banana industry, probably as yet in its earlier stages of development, has assumed large proportions, more than 30,000 acres in the Santa Marta district being under cultivation. Maize is grown as one of the staple foods, and sugar in recent years has become an article of export, and with adequate financial backing from outside, this industry should become of first importance. One property, owned by Colombians, pays enormous annual dividends, and employs, according to season, from 3,000 to 5,000 men. It is an industry that can only expand with foreign capital. Growing without irrigation in certain districts, some canes in fields fifteen years old are still producing without fertilisation and replanting. Planting is done on the Cuban system, a renter being allotted so much cleared land, and when necessary is financed by the owner. Assisted by imported labour, the industry could be largely developed in the Cauca and Quindio Valleys.

Like agriculture, the mining industry of Colombia cannot be said to be developed, and it probably possesses greater possibilities than the former. Its known mineral resources are enormous, but owing to financial reasons, and the lack of transport facilities, comparatively little scientific prospecting and development have accrued. The known minerals embrace nearly all those of commercial importance. Platinum, gold and silver are exported in considerable and increasing quantities. The emeralds of Colombia have long enjoyed an exclusive reputation. The iron deposits have been worked on a small scale. Old copper mines, originally worked by the Indians, are being exploited by crude methods in order to secure copper for domestic appliances, and the mineral is known to exist in various parts of the country. Coal is found in almost every region, but the few mines that have been opened are worked superficially and by crude methods to supply the local demand. The City of Bogota is supplied from exposed ledges of coal on the mountain-side directly above it. Five or six mines are now in operation near Cali on the Pacific Railway, with a total monthly output of about 3,000 tons, but the work is intermittent and the mine equipment antiquated. The Pacific Railway secures its supplies from these mines.

Geologists estimate the coal resources of the country to be about thirty million tons. The Amaga coal-bed, through which runs the Amaga Railway, now being extended to the Cauca River, is said to be very extensive, one property alone having been estimated to contain five million tons of coal. Colombia possesses in this mineral one of its greatest potential resources. The extent of the other known minerals is sufficiently vast to make Colombia a land of immense riches, apart from its agricultural, petroleum and forest wealth, and its cattle-rearing possibilities. It is assuredly this fact, with all the allurements associated with it, that has done much to delay the development of Colombia's mineral resources, for the primary fact is that their efficient development must be subordinate to railway and road construction as in the case of the agricultural development of the country.

Gold-mining in Colombia can only be successful if supported by adequate financial reserves and some knowledge of the country, for it is owing to transportation difficulties and the high cost of making roads and of erecting modern mining machinery that profitable mining in this country is at present improbable except in the case of high grade deposits. There are in the country many millions of tons of low grade ores awaiting exploitation, and many mines showing quite satisfactory returns are worked by foreign capital, and by small native companies, many of which have done extremely well, such as the famous Zancudo mine, which was originally worked for gold, but in latter years the silver output has acquired a greater importance. In general, the principal mining districts are those worked by the Spaniards in Antioquia, Cauca, Santander, and Tolima. In these Departments there are thousands of mines titled but proportionately few in exploitation. Antioquia has always been the chief gold-mining section, and some foreign companies in this Department have done well. The quartz mines that have failed, chiefly with British capital, have hampered development, but before passing judgment on the quality of the ore the success of the native and other companies, which did not invest in expensive machinery, has to be remembered. Again, in this country of auriferous wealth, foreign prospectors not infrequently have their enthusiasm damped by false declarations of values, and by personal discomforts, with the result that independent scientific prospecting is the exception and not the rule. The natives largely use wooden stamp mills with ground sluicing, and " bateas " or native pans, and in spite of this, as previously stated, some of the rich gold mines have produced handsome profits for their owners.

In recent years, owing to the country's navigable waterways, considerable attention has been given by foreign interests to alluvial gold-mining, especially in the Department of Antioquia and the province of Choco, as well as, to a certain extent, in the Departments of Tolima, Bolivia, Caldas and Cauca, which are nearly all auriferous. Alluvial gold-mining dates back to the days of slavery, and in the middle of last century some attention by foreigners was given to this method of collecting gold. In the known alluvial gold-mining regions there are many rivers which are rich in gold alluvials, and there are many advantages in the working of alluvial mines over other mining schemes, for with the aid of modern drills worked either by hand or steam, it is possible to make a close examination of an alluvial deposit to show the number of cubic yards worked per month and the working costs per cubic yard. Knowing from examination the average yield it is possible to estimate the probable earnings. For this reason the working of alluvial gold mines is a fairly safe business proposition; once the amount of gold contained in the sands has been ascertained, it becomes a matter of time and machinery to turn into account the rich contents. In alluvial mining nearly all the work is done by hydraulic or hydro-electric power, and as Colombia possesses a considerable number of large waterfalls, there is exceptional scope for economical development. The water supply can also be used to work monitors and hydraulic elevators.

In Antioquia the entire length of the Porce River from Medellin down to the Nechi River has been worked by the natives, who, however, only work the alluvial beds of small streams, for machinery and modern methods are necessary to handle the great boulders and to bring in water for washing. The Porce is a navigable river and flows into the Nechi River, which is a tributary of the Cauca River, and between these rivers there are many alluvial deposits that have never been examined. The entire region is alluvial in formation and has been practically untouched so far as large mining operations are concerned. The climate is unhealthy, and for this reason the natives are reluctant to come down from their healthier environment on the uplands. Large numbers also prefer to engage in washing for gold on their own account, by the primitive method of washing the sands in " bateas "' or native pans. Several British companies are engaged on alluvial mining in this large district.

In the western part of Colombia, or throughout the large region extending from the Atrato River to the borders of Ecuador, platinum is found with the gold, some rivers containing a larger proportion of platinum, and others of gold. For many years platinum was found with the gold and thrown away as valueless, and at the present time Colombia exports more platinum than any other country. It was first discovered in the placers of the Choco district and its development is due to the two navigable rivers, the Atrato and the San Juan, the former for about 250 miles by steamer, and the latter for some 300 miles with its numerous affluents. At present the two more important districts are the Patia River and its tributaries in the South, and the headwaters of the San Juan and Atrato Rivers. The waters of the San Juan and Atrato Rivers are separated by a short divide of low hills, and the tributaries of these two rivers are at present the scene of extensive mining operations, notably the Condoto and Quito. In the former river district platinum predominates over gold and in the latter gold over platinum. The Opogodo River is now also being worked. There are several English and American Companies with large holdings operating in this platinum region by means of dredging plants driven by mechanical power, but owing to the native population preferring, as in the Antioquian alluvial gold region, to work on their own account, using for this purpose the canoe to explore the rich ground and then move on to more pleasing surroundings, the labour supply is often inadequate.

The mining laws of Colombia are extremely liberal, and every facility is given for the exploration and the " denouncement " of mines. Concessions are limited to an area of 3.68 square miles and are granted for 25-year periods for placer mines and alluvial formations, but when the annual tax for acquiring land is paid, no work need be carried on to preserve the locator's rights. The effect of this in general is that many good mining properties remain undeveloped, owing either to lack of capital or initiative, or until a prospective purchaser comes along, when excessive prices are often demanded. An export duty is payable on platinum at the rate of 5 per cent. *ad valorem*.

The commercial exploitation of the oil resources of the country is of such recent date and is so well known that little need be said of this great development. Its value to the country should be inestimable, not only on account of the money brought into Colombia, but also from the point of view of providing a cheap source of fuel within the country, and in this way accelerating the development of many industries now dependent upon water power, or water supplies which are only available at long distances from where they are required. It should, therefore, be a dual source of wealth to the country. A contract for a national pipeline from the sea-board to the interior has recently been made between a large producing company and the Government. Oil was first produced on a small commercial scale in the middle of 1922. Government concessions are taxed 10% on the gross product, if the land is located 120 miles or less from the coast, 8% if from 120 to 240 miles, and 6% if more than 240 miles. In addition, there is an annual rental of 4 cents per acre in the first year, 8 cents in the second year, 20 cents in the third, and 40 cents each year thereafter until the expiration of the lease, which is for a term of 20 years with an extension of 10 years at the discretion of the Government.

The chief agricultural pursuit in Colombia is cattle-farming, and there is now definite promise of a large export business in frozen meat being developed. Small beginnings have been made following the establishment, mainly with Colombian capital, of the first packing house at Covenas, some 60 miles north-west of Cartagena. This packing-house is capable of dealing with 15,000 head of cattle per month, and according to recent laws, packing houses are exempt from customs duties on imported machinery and in respect of the preparation of all products intended for exportation. Vast pastoral regions amounting to scores of thousands of square miles exist in the country. There are the great *llanos*, which commence at the Eastern Cordillera and extend to the boundaries of Brazil and Venezuela, the Atlantic coast zone, the Magdalena Valley zone up to the City of Neiva, the Pacific zone embracing the large region washed by that ocean, and the Central zone, covering the elevated lands of the interior. It is estimated that there are ten million head of cattle in the country, and that it is capable of rearing many tens of millions, but its future development on any large scale must depend upon the extension of transport facilities. Hides form an important article of export, and it may be mentioned that during the war the British Government caused enquiry to be made in Colombia with a view to establishing a packing house in Colombian territory.

The great national wealth of Colombia's forest products has been little exploited, and can never properly be developed until the difficulty of transportation has been removed. Palm Oil Nuts include the "Corozo," which is used by the Indians and negroes as a vegetable butter and food product, and the "Coneja," which is employed locally for soap-making. The tanning materials exported are mangrove bark, divi-divi pods and quebracho wood. The fibres include the "fique," a species of henequen, and the "Pita," which is used for the same purposes as sisal and hemp and other hard fibres, as well as flax, cotton, and artificial silk. Large areas are occupied by this plant in which some interest is now being taken in foreign markets. The Ceroxylon palm wax has long been used by the Indians for making candles, and a varnish, also used by the Indians, is produced from another palm. Medicinal plants include cinchona, the great forest supplies of which I suggested some 25 years ago might be turned to commercial account by refining the bark in the forest.

The broad survey that has been given is intended to provide an opportunity to discuss the general aspects of the subject of this paper. We know Colombia to be a country largely of unfulfilled promise from the point of view of its resources, but it is certain that the energies of the people are now being directed to productive ends, that marked progress has been made in the past fifteen years, and that given normal conditions it is capable of considerable and profitable development. It is a country of high mountains with a great system of waterways, but of these the two largest, the Magdalena and its tributary, the Cauca, with their respective tributaries, lose much of their commercial value owing to the mouth of the Magdalena River being closed to traffic. We know that the mouth of this river is now being opened and that the railway mileage, though being substantially increased each year, is totally inadequate to meet the demands of the country's possibilities, for, consisting of unco-ordinated sections they were built to satisfy the immediate needs of towns and districts. We know that at the present time Cali is the only capital of an inland Department that is in direct rail communication with the coast. Given, therefore, adequate transport facilities, it is not difficult to foresee developments in Colombia that should bring this Republic into the front rank of Latin-American nations. On its higher uplands it is a country eminently suitable for colonisation by Europeans on a large scale.

DISCUSSION.

THE CHAIRMAN (Mr. Thomas J. Ive) said that the paper had been a very instructive and informative one. They had heard certainly some interesting facts regarding the vast mineral wealth of the country; and the tropical produce of the Republic of Colombia was simply wonderful. Situated at the north of South America, some 450,000 square miles in extent, stretching from the Atlantic to the Pacific, with her seaboards washed by those oceans, Colombia was a country which was blessed by nature to an amazing extent. The author had mentioned the enormous progress that had been made in recent years. The banks had increased from some 47 to 74 in number, representing an increase in capital value of some 600 per cent. The author had also referred to the great progress that had been made with respect to gold mining, silver mining, platinum mining, and the cultivation of coffee, bananas, and other tropical products, as well as the prodigious wealth contained in Colombia in its herds of cattle. Colombia had always had the sympathy of the British. Originally the British provided, or rather lent the Colombians, millions of money for the general purposes of improving the trade of the country, apart from the fact that very many companies had also expended millions of money in building up her trade. At the same time the advance made by Colombia was recognised to-day; while many countries had been going through very trying times with regard to the question of exchange during the last few years, Colombia had steadily improved, until at the present time her money was at par with the currency of the United States; in other words, it was equal to the best in the world. No one could view that progress, however sceptical he might be, without the greatest satisfaction, and that was certainly the case in financial circles in the City of London, which had in the past been so closely associated with the financing of Colombian loans, enterprises, etc. But if he might issue one word of warning, it would be to ask Colombia to realise that in spite of her wonderful growth, the development of such a country did present difficulties on account of its great area and relative want of communication. The return on capital invested or asked to be invested must be greater than that which would be the case (say) a hundred years hence, or fifty years hence, when the developments would naturally make it easier to exploit natural resources. He had been very pleased to hear a description of the Cauca Valley, which was mentioned by Humboldt as being the paradise of the world. He had been out in Colombia very many times, and he remembered the first time going up the Cauca Valley on the railway with a friend who had travelled very much, and this friend had pointed out that the Cauca Valley was the fifth finest valley in the world. Certainly it was a most remarkable sight—so astonishing, indeed, that it was really impossible for him to describe it; but he had the finest memory of it, and every time he passed up the valley he admired it more. Mr. Thomson had referred also to the advance of Colombia during the century from 1810 to 1910. He could claim that he and his friends had helped considerably in that development. They had spent several hundred thousands of pounds in machinery, which had brought considerable revenue to the Republic, and they had spent many thousands of pounds in the employment of labour. Wherever they had formed a camp they had introduced sanitation, as was usual with the British, to the great advantage of the native population. They had sent out medical officers who had been of inestimable value to the people in the districts in which they had been working; and Colombia had benefited largely from the work of British engineers. He sincerely trusted that the Government of Colombia would always consider very carefully the interests of the British who were doing so much pioneer work, so much good, useful and helpful work in the development of the wonderful country.

MR. ARTHUR CAMPLING said he had listened with great interest to Mr. Thomson's paper. As one who had had a great deal of trade with Colombia for the last twenty years, and who had been very much interested in the railway development of the country, he was specially interested in the author's reference to the great difficulty of transport. It was true that British enterprise and help had assisted Colombia to develop itself by means of the railways. He would be glad if Mr. Thomson could give some idea of any adumbrated railway schemes at present on the tapis. The old Colombian National Railway, which was financed in England, had been taken over by the Government, and was now, he thought, the Girardot Railway, the last of the British-financed railways taken over.

MR. NORMAN THOMSON replied that there were various general schemes in Colombia for railway development. The loan, to which he had referred in his paper, of 100,000,000 dollars which had been authorised by the Colombian Government the previous year, specified the suggested new routes to be taken by the new lines, one of which was from Cartagena to Antioquia, another to link up Antioquia with Popayan, and so on, as mentioned in the paper.

H.E. THE COLOMBIAN MINISTER (DR. LUIS CUERVO MARQUEZ) said that he had heard with deep interest the important paper given by Mr. Norman Thomson, and he admired his knowledge of Colombia. He appreciated also the words of the Chairman and the other gentlemen who had spoken, and he thanked them for the kindly and friendly opinions that had been expressed. Colombia was, as had been said, a country of immense natural resources. She possessed rich mines of iron, gold, silver, platinum, emeralds; plenty of coal and waterfalls for power development; extensive forests; many kinds of textiles; splendid grasses; wide navigable rivers; long coast lines on the two oceans, and, in addition to all those sources of wealth, a settled Government and a peaceful and energetic people. All foreign help which could contribute to develop her progress was welcomed by Colombia. But British people and British capital had the preference, because Colombians knew from many years' experience the honesty of British methods and the soundness of British enterprises.

DR. GABRIEL POSADA VILLA (member of the Colombian Government) said that at the present moment he did not know what the Government of Colombia was intending to do, as Congress was still in session. He had come to England as a member of the Financial Mission with the intention of consulting the bankers of the Republic in London. The bankers had suggested that the Colombian debt should be converted as a preliminary step before the Colombian Government raised any further loans for the purpose of railway development. There were at the present time six different debts, as Mr. Thomson had said, amounting in all to scarcely more than £4,000,000, and they were difficult to deal with on account of the different conditions as regards security, and of the different yields in interest. That made it difficult for Colombia to raise loans for railroad construction, because there was really no basis on which to found the credit of the Republic for the present. The intention of the Government had, therefore, been to consolidate those debts, and to convert them into one form of bond very well secured on the Customs revenue. After that the way would be prepared for further loans to be raised for future railroad construction. In the meantime the Government was employing the amount it was receiving from the Government of the United States in respect of the indemnity for the Panama Canal, at the rate of $5,000,000 a year, in extending some of the principal trunk lines. The principal lines on which the money was being expended were the lines running from Bogota towards the sea on one side of the river, going through three of the most important and densely-populated departments of Colombia, and on the other side the extension of the Pacific line from Buenaventura towards the Cauca River and towards the Atlantic side. Of course, what happened elsewhere happened also in Colombia—namely, that almost every citizen in every city wanted a railroad of his own. That was the principal difficulty; but the Government was spending the money on the principal lines, and simply making preliminary studies of the other lines. The money was not being thrown away. In the near future he expected that the Government would find out what was the most convenient and truly national railroad to be built, and the money would be spent on proper commercially and nationally valuable railways. The currency of Colombia was at a slight premium. There was, of course, a difference in the foreign values and the commercial values, but the currency was supported by gold, and it was expected that the money from the indemnities was going to be well spent, and that after the preliminary work was finished it would be possible to make contracts for railroad construction, by means of payments made in cash with the money obtained from the sale of the new bonds, up to the amount authorised in conversion agreement, when the conversion of the debt was carried out as projected by the Government.

Mr. Archer Turner said he thought the Colombian Government ought to pay more attention to their roads than they did at present. All the money went in railroads, and railroads were very expensive to build, and costly to keep up when built. A road was very much cheaper to build, and it would be better for the country to spend its money on improving the roads until the time came when it could afford to build a railway. There were at present very few miles of cart road outside the principal towns.

Mr. C. G. Inder said that nature had endowed the Colombian nation with one of the most magnificent countries in the world. He had not time to go into detail, but what one felt was that Colombia wanted a larger population and better means of communication She must have those two assets. Apropos of that, Mr. Thomson had left out of his paper, interesting as it was, one important point—namely, electricity. That was an extremely important point, because as one crossed those splendid mountains the Cordilleras, and saw the wonderful rivers running from 10,000 or 11,000 feet above sea level, tumbling over hundreds of feet of falls, it required little imagination to conceive of Colombia in fifty years when full use had been made of its potentialities in the application of electricity. Enormous power was available. If he might make a suggestion to Colombia it would be that she must realise to-day that she had to be generous to those who wanted to do work in the country. He did not for a moment suggest that the Colombians had not been generous; they had been magnificent to the original *entrepreneurs*; but the benefits that would accrue to the country as a result of the development of her communications, and the natural opening up of the resources that would go with that development, would be such that terms that looked absurd to-day would look magnificent to the future Colombians. A good idea of the potential resources of Colombia had been given in the interesting pictures that had been shown. Alongside Bogota there were thousands of acres of magnificent savannah land, with soil five or six feet deep, on which there was hardly a plough to be seen. To-day in England intensive cultivation and fertilisers were being used, to an extent which Colombia did not need; but if one imagined the railways of Colombia developed to the full extent, worked perhaps by electricity—at any rate, by the cheapest power—one could then see that the millions of carcases of cattle would be carried to Europe instead of the hides only as was the case to-day. One could go on for a long time speaking of such things; but as one who had had a good deal of experience in pioneer work he would only say that the Colombian laws towards the miners were generous; they were well founded and well drafted; and those who wished to conform to the local peculiarities, the local temperament, the local conditions, need not fear to get anything but fair treatment from Colombia. There were points, in fact, —if he might suggest it with all due deference to His Excellency the Colombian Minister—where the Colombians had been too generous to the original exploiters of mines; so much so that many people had denounced the mines and sat on them. Those were not the sort of people who were wanted for the development of the country; they simply held mines, in return for the payment of taxes of small amount without developing them. For the present the Colombian Government must be generous to those who would actually develop the resources of the country. He was not personally interested in the matter, but the man to help was the man who was actually spending the money and had the ability to do so. The particular district in which he was interested was the Chocó. He had been in that district when the natives wore the pampanilla. To-day they wore the pantaloon. That had been done by the engineer. The engineers had taken the money, mostly from London, and put it into circulation, and they had developed the country to such an extent that that change had taken place. The change from the pampanilla to the pantaloon was not a joke; it was a true indication of what the negro in the Chocó had passed through by the aid of one or two companies. If one imagined those things multiplied by 50 or 100, one would realise what development had taken place. That development would be admitted by anybody who had visited Colombia. Colombia required capital, energy, and communications. She must naturally want to develop those resources herself, but such was the population, such had been the difficulties of education and of cultivating the right type of men, that she must be content to use British and other foreign ability and enterprise for yet a little longer; and the teaching of the craftsmen of Colombia would grow with the development of the natural resources.

On the motion of the Chairman a vote of thanks to the author of the paper was carried unanimously.

Mr. Norman Thomson, in reply, said that in reviewing a country it was difficult to go closely into the various aspects; one could only deal with the subject broadly. With regard to the question of the utilisation of the water-power of the country, in his paper he had incidentally mentioned that sixty hydro-electrical plants had been erected in Colombia in the last few years. That short statement was intended to suggest the possibilities of water-power development in the country. The country was vast, and its resources could only be sketched in such a paper as he had given. At present it was a country with possibilities which were gradually becoming probabilities. He remembered Colombia thirty years ago, when transport was effected by means of the mule and the canoe. Colombia to-day was a different proposition. Railways had been built, and transport was vastly improved. The Magdalena and the Cauca were the largest rivers in the country. Inland towns at present shut off by the closed mouth of the Magdalena would on its being opened enable traffic from these inland towns to reach the coast.

The Chairman tendered the thanks of the meeting to His Excellency the Colombian Minister for attending. Unfortunately Mr. Medina, of the Colombian Bureau of Information, had been called away to Colombia on account of family affairs; otherwise he also would have been present at the meeting. He was most energetic in his work for the Colombian Information Department, and he (the Chairman) would convey the thanks of the meeting to Mr. Medina for his help in that direction.

OBITUARY.

Professor George Downing Liveing, Sc.D., F.R.S.—Professor George Downing Liveing, who was elected a Life Fellow of the Society in 1874, died at Cambridge on December 26th, at the age of 97. Born in 1827, he was educated at St. John's College, Cambridge. He read for the Mathematical Tripos and was eleventh Wrangler in 1850, and in the following year he sat for the newly established Natural Sciences Tripos, in which he was first of six candidates, with distinction in Chemistry and Mineralogy. After studying for a short time in Germany, he returned to Cambridge, being elected a Fellow of his College in 1853. The St. John's College Laboratory was then built, and Liveing was the first man to teach science experimentally at Cambridge.

In 1860 he was appointed Professor of Chemistry at the Staff College and the Royal Military College, Sandhurst. In 1861 he succeeded James Cumming as Professor of Chemistry in the University of Cambridge. At that time the accommodation at his disposal was ridiculously inadequate, and there were no facilities whatsoever for teaching practical chemistry. By his energy and organising power, however, Liveing was able in course of time to build up a flourishing school, with the result that in 1888 Cambridge possessed one of the finest laboratories in the country.

In 1911 Dr. Liveing was appointed President of St. John's, a post which he occupied until his death. He had been elected a Fellow of the Royal Society in 1879, and in 1901 he was awarded the Davy Medal "for his spectroscopic papers, which, mainly published during the last quarter of a century in conjunction with Professor Dewar, make up a record of patient, accurate, conscientious labour and taken together constitute one of the most valuable contributions to this department of chemical physics yet made by British workers."

LA VIE INDUSTRIELLE EN FRANCE.

La Résistance des Rails de Chemins de Fer et leurs Essais de Réception.

Les rails de chemins de fer sont sujets à des ruptures fréquentes—il s'en produit plusieurs milliers par an dans le monde entier—et ces ruptures occasionnent souvent des accidents. D'autre part, leur usure normale sur les grandes lignes est importante et irrégulière.

Un savant ingénieur français, M. Ch. Fremont, qui étudie depuis longtemps la résistance des métaux (l'Iron and Steel Institute lui a décerné récemment sa grande médaille Bessemer), a déterminé le mode d'usure des rails, et a élaboré une méthode d'essai qui permet de vérifier si le métal possède les qualités nécessaires.

Les expériences de M. Fremont lui ont montré que l'usure des rails n'est pas un phénomène d'abrasion, c'est un phénomène de choc. La surface de contact de la roue avec le rail n'est que de 80 mm^2 (0 sq. in. 16) environ, et la charge n'est appliquée que sur cette surface que pendant 1/2.500ème de seconde pour un train circulant à 72 kilomètres à l'heure ; elle produit donc l'effet d'un véritable martelage. Cette action dynamique, proportionnelle à la vitesse du train, déforme le rail d'une manière permanente et sur une très faible épaisseur. Cette déformation s'effectue transversalement, parce que l'écoulement du métal dans ce sens éprouve moins de résistance que longitudinalement.

Pour résister avantageusement à l'usure, l'acier des rails doit donc présenter à la surface de roulement une limite d'élasticité élevée, surtout dans le sens transversal au laminage. Pour que cette résistance soit maximum, il faut que le métal ne contienne pas d'inclusions de scories, ni de traces de ségrégation. Il faut aussi que l'acier ne soit pas trempant.

Dans un récent mémoire qui résume ses derniers travaux, M. Fremont propose pour l'essai des rails, d'une part l'essai de fragilité, c'est-à-dire l'essai au choc sur rail entaillé, et d'autre part, l'essai de dureté effectué au moyen d'une molette tranchante. Il conclut que l'on doit employer, pour constituer les rails, des aciers demi-durs, ne dépassant pas 60 kgs. de résistance de rupture à la traction, mais d'une résistance finale (au moment de la rupture) élevée, atteignant au moins 115 kgs. Cet acier doit être non trempant.

En outre, il est indispensable de n'utiliser que des aciers non contaminés par la ségrégation et les inclusions du lingot, car ces impuretés sont, avec la fragilité, la cause des avarie et des ruptures accidentelles des rails.

LE REVÊTEMENT DES ROUTES AU SILICATE DE SOUDE.

La chaussée macadamisée suivant le procédé classique est aujourd'hui condamnée pour toutes les routes à grande circulation, et surtout à circulation d'automobiles lourdes. On a essayé de remplacer le macadam par les petits pavés ou les briques, les macadams à liants bitumineux, le béton armé ou non armé. Tous ces procédés sont coûteux, surtout en France, où les liants bitumineux sont le plus souvent importés de pays à change élevé. Un procédé assez économique, la silicatisation, a été préconisé depuis deux ans par M. Guelle, Ingénieur des Ponts & Chaussées à Besançon : ce procédé a été essayé d'abord dans le département du Doubs, puis en Seine-et-Marne et jusque dans la banlieue de Paris.

Il s'agit de l'incorporation, aux matériaux pierreux de la chaussée, d'une certaine quantité de silicate de soude $Si O^3 Na^2$, fabriqué par la calcination d'un mélange de sable pur et de carbonate de soude. La dissolution de ce corps dans l'eau est livrée en tonneaux et a pour densité environ 1,4.

Après qu'on a bien préparé la forme de la chaussée (par un labourage mécanique, s'il s'agit d'une chaussée ancienne et abîmée), on dépose sur un plancher, qui suit l'avancement du chantier, 1 mètre cube de pierre calcaire demi-dure et 350 litres de matière d'agrégation, par exemple de la même pierre finement concassée. On arrose avec 40 litres de silicate de soude. Le tout est brassé avec des pelles et des griffes, ou avec un malaxeur.

Du plateau, le mélange est jeté à la pelle sur le lieu d'emploi ; la forme est réglée approximativement à l'aide de piquets, en tenant compte du tassement (un quart environ) et du bombement désiré. Le cylindrage s'effectue ensuite avec un rouleau pas trop lourd.

Le durcissement se fait en deux jours environ, pendant lesquels on ne doit pas laisser circuler sur la chaussée.

Une équipe de 15 hommes peut couvrir 400 m. carrés par jour.

Outre son prix de revient peu élevé (15 francs environ le mètre carré), la chaussée silicatée a d'autres avantages : elle est monolithe et ne présente pas de fissures ; l'exécution est rapide ; les réparations sont faciles, peu onéreuses et leurs traces s'effacent rapidement ; elle n'est pas poussiéreuse, grâce au colmatage provoqué par le silicate, et elle n'est pas sonore.

LA PROSPECTION DU PÉTROLE EN FRANCE.

La Section de géologie du Comité scientifique du Pétrole s'est réunie dernièrement pour examiner les derniers travaux relatifs à l'exploitation du pétrole en France ou aux Colonies. Un jaillissement s'est produit tout récemment à Gabian dans le département de l'Hérault (sud de la France), et il semble dénoter la présence d'un gisement exploitable. D'autres forages vont être exécutés.

D'autre part, un nouveau forage va être exécuté dans le Puy-de-Dôme, pour compléter l'exploration de la région de la Limagne, qui a déjà donné des résultats encourageants.

Enfin, un programme général d'exploration géologique de l'île de Madagascar a été élaboré et il doit être prochainement mis à exécution. Il comporte l'exploration des régions voisines de celle déjà étudiée entre le Manambe et le Ranobe. On doit aussi créer un centre d'études et un laboratoire pour l'exécution d'essais semi-industriels de traitement de grès bitumineux.

On fonde beaucoup d'espérances, en France, sur la production pétrolière future de Madagascar.

LE CURAGE DES EGOUTS PAR LA PRESSION ATMOSPHÉRIQUE ET L'ÉPURATION DU SEWAGE.

La commune de Villeneuve-St.-Georges, qui fait partie de la banlieue sud de Paris, compte environ 20,000 habitants, dont les demeures s'espacent entre la Seine et les coteaux limitant sa vallée, sur une vaste étendue. La plus grande partie de l'agglomération étant en plaine, et à quelques mètres seulement au-dessus de la Seine, l'évacuation des eaux usées présentait des difficultés, faute de la pente nécessaire dans les égouts. Aussi a-t-on adopté, suivant le système préconisé par l'ingénieur Gandillon, un mode d'évacuation pneumatique du sewage, qui mérite d'être signalé. Disons d'abord que les eaux de pluie, assez propres pour ne pas engorger les égouts et pour être rejetées à la Seine dans épuration préalable, sont simplement envoyées au fleuve par un ensemble de canalisations du type usuel. C'est seulement aux eaux-vannes des habitations que s'applique le système pneumatique.

Chaque groupe de trois ou quatre immeubles voisins est desservi par un premier réservoir où se rassemblent les tuyaux de descente des eaux-vannes ; ces réservoirs sont eux-mêmes reliés à des réservoirs de quartier par des canalisations en fonte bien étanches, et enfin ceux-ci sont reliés aux deux grands réservoirs de l'usine d'épuration par un collecteur principal, également en fonte, et étanche. Comme la pente ne suffit pas à faire écouler les matières boueuses dans ce réseau, on y opère à intervalles fréquents des curages énergiques, en faisant le vide dans le collecteur au moyen des pompes aspirantes de l'usine. On ouvre ensuite les vannes de fermeture des réservoirs de quartier, puis des petits réservoirs, et la pression atmosphérique qui s'exerce brusquement, par les tubes dechute des immeubles, sur le réseau de canalisations en fonte où l'air a été raréfié, chasse violemment tout leur contenu jusque dans les grands réservoirs de l'usine.

Celle-ci est pourvue, d'autre part, de cuves en ciment armé où se fait l'épuration biologique, de façon que l'effluent puisse être envoyé sans danger dans la Seine.

NOTES ON BOOKS.

ROUBILIAC'S WORK AT TRINITY COLLEGE, CAMBRIDGE. By Katharine A. Esdaile. Cambridge: at the University Press. 7*s*. 6*d*. net.

This monograph with its score of plates dealing with Roubiliac's work at Trinity College, Cambridge, gives one a good idea of the points in which the sculptor particularly excelled. The busts are, indeed, a remarkable series. "I know of no works which may be safely compared to them," said Chantrey. "They have a manly and vigorous freedom of manner which proves to me that he treated them rather in the manner of the heads of statues than as domestic portraits, where fidelity of resemblance is more aimed at. Those who have not seen the Cambridge busts, and above all the statue of Newton, are strangers to the best work of Roubiliac."

Of the Newton statue, which inspired Wordsworth's fine lines

"The marble index of a mind for ever
Voyaging through strange seas of thought alone,"

Mrs. Esdaile relates a curious tradition told to her by the sculptor's great-great-granddaughter. "When Roubiliac came to carve the hand holding the prism, he had to modify the original pose owing to an unexpected flaw in the marble. In what that alteration consisted I have been unable to learn, but every fragment of anecdote is of value; where a work of art so noble is concerned, and as this is unpublished, it is worthy of record where the field of Trinity tradition is so barren."

It certainly would be interesting to know how the sculptor had originally intended to pose the hand. There is nothing in its present position to suggest that it was forced upon him by a sudden mischance.

The plates impress one afresh with Roubiliac's skill in dealing with the hair and the details of draperies, and also with his happy manner of finishing off the busts, so that they suggest the upper parts of statues and do not present the " cut off " appearance common to so many of their kind.

It is very unfortunate that, as Mrs. Esdaile remarks, eighteenth century sculpture has long been out of fashion in England. This little book is sufficient to show that Roubiliac's work still deserves careful study, and we hope that the volume will send many readers to discover its strength and its beauties.

ENGLISH FURNITURE AT A GLANCE. By Charles H. Hayward. London: The Architectural Press. 5*s.* net.

The Architectural Press are publishing a useful series, the first volume of which is " English Architecture at a Glance," and the second is the book under notice. The series is designed for those who desire to obtain an elementary knowledge of the subject dealt with, and the method adopted is to give a simple and concise narrative, illustrated by pictures of typical specimens, of the origin and evolution of the types described. Thus, a very brief introduction sketching the general evolution of furniture and the woods employed from Tudor to Georgian times, is followed by a chapter on " Stools," with eight illustrations, showing the development of the stool from the solid Tudor Gothic, through the Elizabethan, Jacobean, Caroline, William and Mary, and Queen Anne periods, to the mahogany Chippendale stool. Subsequent chapters deal similarly with settles, chests, tables, beds, wardrobes, china cabinets, bookcases, mirrors, and other pieces.

The illustrations have been chosen with much care, and the book appears to be excellently suited for the purpose in view.

COTTON GROWING IN EAST AFRICA.

Steady progress is being made with the scheme for cotton growing in the Kavirondo district (Kenya Colony) near Lake Victoria, writes Colonel Franklin, H.M. Trade Commissioner in East Africa, in his annual report. Four ginneries are in process of erection and one buying post has been allocated. It is intended to levy the same tax as in Uganda, viz., 6 cts. per lb. of lint exported.

Colonel Franklin again records a marked improvement in the quality of the ginned cotton in East Africa, mainly, in the case of Uganda, due to the fuller realisation of the necessity of care in all stages of handling this valuable crop, and, in Tanganyika Territory, as the result of technical work undertaken by the Empire Cotton Growing Corporation. It is hoped that this work will result in a hybridised plant capable of successful and uniform cultivation on a large scale in Tanganyika. An increasing interest is being taken in the possibility of the Mwanza district as a cotton growing centre, there being three ginneries there now. Two more are in course of erection and two are contemplated. Also, additional road improvement is being undertaken in Uganda and Kenya, not only to improve the transport service but also to open up new districts for cotton cultivation.

So far all this cotton has been grown by natives, but in Tanganyika Territory there are now a number of estates growing cotton under European management, either as a full-time or rotation crop, which may lead to great developments.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock, unless otherwise announced:—

JANUARY 21.—MRS. GRAYDON-STANNUS, "Irish Glass, Old and New." SIR HERBERT JACKSON, K.B.E., F.R.S., will preside. Specimens of the glass will be exhibited.

JANUARY 28.—CHARLES A. BAKER, M.I.E.E., Assistant Engineer, London County Council, "The Electrical Equipment of the London County Hall." SIR GEORGE HOPWOOD HUME, M.P., Alderman, London County Council, will preside.

FEBRUARY 4.—SIR ERNEST RUTHERFORD, O.M., M.A., D.Sc., F.R.S., *Trueman Wood Lecture*, "The Stability of Atoms."

FEBRUARY 11 (at 4.30 p.m.).—SIR J. FORTESCUE FLANNERY, Bt., Past-President of the Institute of Marine Engineers, "The Diesel Engine in Navigation." LORD BEARSTED, LL.D., will preside.

FEBRUARY 18.—J. S. OWENS, M.D., Assoc.M.Inst.C.E., F.G.S., Superintendent Advisory Committee on Atmospheric Pollution, Air Ministry, Meteorological Office, "Modern Atmospheric Conditions."

FEBRUARY 25.—SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., "The Power of Internal Combustion Engines for Motor Cars." THE HON. SIR CHARLES A. PARSONS, K.C.B., LL.D., D.Sc., F.R.S., will preside.

MARCH 4.—PROFESSOR W. E. S. TURNER, O.B.E., D.Sc., F.Inst.P., Department of Glass Technology, University of Sheffield, "The Modern Production of Sheet-Glass."

MARCH 11.—EMILE CAMMAERTS, "The Restoration of Public Buildings in Belgium."

MARCH 18.—CLAUDE N. FRIESE-GREENE, "Colour Cinematography."

MARCH 25.—HENRY G. DOWLING, "Wall-papers."

Dates to be hereafter announced:—

MAJOR-GENERAL SIR WILLIAM SEFTON BRANCKER, K.C.B., Director of Civil Aviation, Air Ministry, "Commercial Aviation."

CEDRIC CHIVERS, "Bookbinding."

C. R. PEERS, C.B.E., F.S.A., Chief Inspector of Ancient Monuments and Historic Buildings. (Subject to be announced later.)

LIEUT.-COLONEL ANDREW BALFOUR, C.B., C.M.G., M.D. (Edin.)., B.Sc. D.P.H., F.R.C.P.E., "The Trend of Modern Hygiene."

DAVID GREENHILL, "Colour Printing."

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock:—

FEBRUARY 6.—J. T. MARTEN, M.A., I.C.S., "The Indian Census." SIR EDWARD ALBERT GAIT, K.C.S.I., C.I.E., Ph.D., will preside.

MARCH 6.—SIR HENRY SHARP, C.S.I., C.I.E., M.A., "The Development of Indian Universities."

MAY 8.—SIR GILBERT T. WALKER, C.S.I., M.A., F.R.A.S., Sc.D., Ph.D., F.R.S., "Indian Meteorology."

JUNE 12.—BRIGADIER-GENERAL SIR PERCY M. SYKES, K.C.I.E., C.B., C.M.G., "The Heart of Asia and the Roof of the World."

Date to be hereafter announced:—

SIR ALFRED CHATTERTON, C.I.E., Assoc.M.Inst.C.E., "The Industries of the Mysore State."

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons, at 4.30 o'clock, unless otherwise announced:—

JANUARY 27.—WALTER RONALD DUNLOP (late Professor of Economics, Imperial College of Tropical Agriculture), "Economic Research in Tropical Development." SIR HALFORD J. MACKINDER will preside.

FEBRUARY 24.—R. H. BRACKENBURY, Member of the Empire Cotton Growing Corporation Mechanical Transport Sub-Committee, "Transport in Tropical Africa."

Dates to be hereafter announced:—

HON. W. G. A. ORMSBY-GORE, M.P., Under Secretary of State for the Colonies. (Subject to be announced later.)

LORD BLYTH, "Penny Postage and Postal Communications Generally."

DOMINIONS AND COLONIES AND INDIAN SECTIONS. (JOINT MEETING).

Date to be hereafter announced:—

LORD STEVENSON, G.C.M.G. (Chairman, Standing Committee of British Empire Exhibition), "The British Empire Exhibition." SIR CHARLES CAMPBELL MCLEOD, Bt. (Chairman of the Finance Committee of the Exhibition) will preside.

CANTOR LECTURES.

Monday evenings, at 8 o'clock:—

V. E. PULLEN, Director, Radiological Research Department, Woolwich, "Radiological Research—A History." Three Lectures. January 19, 26, February 2.

WALTER ROSENHAIN, B.A., B.C.E., D.Sc., F.R.S., Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory, "The Inner Structure of Alloys." Three Lectures. February 16, 23, March 2.

HOWARD LECTURES.

Monday evenings, at 8 o'clock:—

PROFESSOR JOHN SAMUEL STRAFFORD BRAME, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, "Motor Fuels." Three Lectures. April 20, 27, May 4.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, JANUARY 12..Surveyors' Institution, 12, Great George Street, S.W., 8 p.m.

Transport, Institute of (Yorkshire Section) Town Hall, Leeds, 5.30 p.m. Inaugural Address by the Chairman, Mr. J. B. Hamilton.

Geographical Society, 135, New Bond Street, W., 8.30 p.m. Major R. W. G. Hingston, "Animal Life at High Altitudes."

Architectural Association, 34, Bedford Square, W.C., 8. p.m. Sir Owen Williams, "The Engineering Work at Wembley."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 7 p.m. (Informal Meeting). Discussion on "Telephonic Development in Great Britain and in the United States."

(Western Centre) Merchant Venturers' Technical College, Bristol, 6 p.m. Address by the President, Mr. W. B. Woodhouse.

Automobile Engineers, Institution of, Chamber of Commerce, New Street, Birmingham, 7 p.m. Dr. S. S. Pickles, "The General Manufacture of Rubber."

Metals, Institute of (Scottish Section), 39, Elmbank Crescent, Glasgow, 7.30 p.m. Open Discussion.

Victoria League, 22, Eccleston Square, S.W., 5 p.m. Sir Herbert Maxwell, "Bannockburn."

Brewing, Institute of, 39, Coventry Street, W., 7.30 p.m. Mr. J. Stewart, "The Season's Barleys."

TUESDAY, JANUARY 13..Automobile Engineers, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C., 7 p.m. Dr. S. S. Pickles, "The General Manufacture of Rubber."

Metals, Institute of, (N.E. Coast Section) Armstrong College, Newcastle-on-Tyne, 7.30 p.m. Mr. A. R. Page, "Brazing."

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. A. W. Fowler, "The Analysis of Spectra," (Lecture I).

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Sir Francis Newton, "Southern Rhodesia."

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m.

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m. 1. Prof. A. H. Gibson, "The Investigation of the Surge-Tank Problem by Model Experiments."
2. Mr. F. Heywood, "The Flow of Water in Pipes and Channels."

Electrical Engineers, Institution of, (N. Midland Section), Hotel Metropole, King Street, Leeds, 7 p.m. Address by the President, Mr. W. B. Woodhouse.

Supervising Electricians, National Association of, St. Bride's Institute, Bride Lane, Fleet Street, E.C., 7.15 p.m. Mr. H. R. Leslie Groom, "Modern Developments of Stage Lighting."

WEDNESDAY, JANUARY 14..Design and Industries Association, at the London School of Economics and Political Science, Houghton Street, W.C., 5 p.m. Mr. B. J. Fletcher, "The Principles of Design."

Civil Engineers, Institution of, Great George Street, S.W., 7 p.m. (Informal Meeting). Mr. H. P. Deane "The Use and Abuse of Reinforced Concrete."

United Service Institution, Whitehall, S.W., 3 p.m. Mr. C. E. Fayle, "Maritime Power and Continental Alliances."

Electrical Engineers, Institution of, (S. Midland Section), The University, Edmund Street, Birmingham, 7 p.m. Mr. H. W. Taylor, "Three-Wire Direct-Current Distribution Networks, Some Comparison in Cost and Operation."

THURSDAY, JANUARY 15..Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Royal Institution, Albemarle Street, W., 5.15 p.m. Mr. J. S. Huxley, "The Courtship of Animals and its Biological Bearings." (Lecture I).

Chemical Society, Burlington House, Piccadilly, W., 8 p.m.
1. Messrs. E. E. Turner and A. B. Sheppard. 6-Chlorophenoxarsine.
2. Messrs. G. A. R. Kon and R. P. Linstead. (*a*) The Chemistry of the three-carbon system. Part III. $\alpha\beta$-$\beta\gamma$ change in unsaturated acids.
3. (b) The Chemistry of the three-carbon system. Part IV. A case of retarded mobility.

Tropical Medicine and Hygiene, Royal Society of, 11, Chandos Street, W., 8.15 p.m. Colonel Gage and Colonel Clayton Lane, "The Alkaloids of Cinchona and Malaria."

Mineralogical Society, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

Mechanical Engineers, Institution of (Midland Branch), Queen's Hotel, Birmingham, 5.30 p.m. Annual Meeting.

Victoria and Albert Museum, South Kensington, S.W., 6 p.m. Prof. J. H. Worthington, "The Elements of Artistic Design as illustrated by English Buildings in the 18th Century."

FRIDAY, JANUARY 16..Chemical Industry, Society of (London Section, Engineering Group), at the Royal Society of Arts, John Street, Adelphi, W.C., 8 p.m. Mr. T. W. S. Hutchins, "The Low Temperature Treatment of Bituminous Materials."

Royal Institution, Albemarle Street, W., 9 p.m. Sir William Bragg, "The Investigation of the Properties of Thin Films by means of X-Rays."

Central Asian Society, at the Royal United Service Institution, Whitehall, S.W., 5 p.m. Lt.-Colonel J. H. M. Cornwall, "Turkey To-Day."

Geologists' Association, University College, Gower Street, W.C., 7.30 p.m. Mr. T. W. Marsh, "The Alongshore drifting of Beach Material."

Sanitary Institute, Town Hall, Newcastle-upon-Tyne, 4 p.m.
1. Dr. A. F. G. Spinks, "Maternity and Child Welfare Practice."
2. Mr. H. G. Hilton, "Cleansing and House Refuse Removal in Newcastle-upon-Tyne."
3. Mr. T. Parker, "Elimination of the Tuberculous Cow."
4. Mr. C. Raines, "The Sanitation of the Cinema."

Metals, Institute of (Local Section), University College, Singleton Park, Swansea, 7.15 p.m. Prof. C. A. Edwards, "Alloys and their Properties."

Engineers, Junior Institution of, 39, Victoria Street, S.W., 7.30 p.m. Major A. M. Taylor, "Electrical Power Transmission at 150,000 Volts and Upwards."

SATURDAY, JANUARY 17..Royal Institution, Albemarle Street, W., 3 p.m. Mr. G. Gordon, "The Women of Shakespeare."

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No 3765 VOL. LXXIII.

FRIDAY, JANUARY 16, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

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NEXT WEEK.

MONDAY, JANUARY 19th, at 8 p.m. (Cantor Lecture.) V. E. PULLIN, Director, Radiological Research Department, Woolwich, " Radiological Research—A History." (Lecture I.)

WEDNESDAY, JANUARY 21st, at 8 p.m. (Ordinary Meeting.) MRS. GRAYDON-STANNUS, " Irish Glass, Old and New." (Specimens of the glass will be exhibited.) SIR HERBERT JACKSON, K.B.E., F.R.S., will preside.

INDIAN SECTION.

FRIDAY, 9th JANUARY, 1925; THE HON. VICARY GIBBS in the Chair.

The sixth Sir George Birdwood Memorial Lecture, " Government Botanical Gardens," was delivered by LIEUT.-COLONEL SIR DAVID PRAIN, C.M.G., C.I.E., LL.D., F.L.S., F.R.S., I.M.S., late Director of Royal Botanic Gardens, Kew.

The lecture will be published in a subsequent number of the *Journal.*

BINDING COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their annual volumes of the *Journal,* cloth covers can be supplied, post free, for 2s. each, on application to the Secretary.

TEN-VOLUME INDEX TO "JOURNAL."

The amalgamated Index to the *Journal of the Royal Society of Arts* for Vols. LXI.-LXX. (1912-1922) is now ready, and can be obtained by Fellows of the Society on application to the Secretary, Royal Society of Arts, John Street, Adelphi, London, W.C.

Some copies of the ten-volume indexes for Vols. I.-X. (1852-62), XI.-XX. (1862-72), XXXI.-XL. (1882-92), XLI.-L. (1892-1902) and LI.-LX. (1902-1912) are still in stock, and can also be obtained by Fellows on application. The index for Vols. XXI.-XXX. (1872-82) is out of print.

The price to non-Fellows of each index is 2*s.* 6*d.*

PROCEEDINGS OF THE SOCIETY.

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CANTOR LECTURES.

MODERN COLOUR PROBLEMS.

By Louis C. Martin, D.Sc., A.R.C.S., D.I.C., F.R.A.S.,

Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and Technology.

Lecture I.—*Delivered November 24th*, 1924.

It is of no little interest to speculate upon the nature of the criticisms which future ages will pass upon the scientific culture of the present time. The unparalleled expansion of natural knowledge during the nineteenth and early twentieth centuries will be seen as the harvest derived from patient efforts in previous times, more especially from the Renaissance onwards. The growth and development of popular education in scientific subjects is indispensable in the present conditions of our mushroom-grown industrial civilisation; but the examination system, which is at present a vital part in the existing educational machine, has not only constrained the progress of culture along extremely arbitrary lines, but has constantly retarded the development and advance of thought on many subjects. Thus it chances that the study of colour, one of the most fascinating and educational regions of applied optics, and incidentally a subject of no little practical and industrial importance, receives scant attention at the present time. It demands a range of study much beyond the narrow limits of examination subjects. Certainly these arbitrary divisions of knowledge* are the most amazing feature of the Natural Science of our own time, and while they will receive severe condemnation from future ages, the past also condemns them with no uncertain voice.

In order to deal adequately with problems of colour and colour measurement, it is necessary to study the nature of light and the mode of action of some optical instruments; the functions of the eye and the psychology of colour vision must also receive their due share of attention. It is clearly impossible to restrict such a study within the bounds usually ascribed to physics, physiology or psychology. Nevertheless, in the present condition of science which attributes to "things" a reality and concreteness of a type not associated with thought and sensation, we feel bound to begin with the study of the more objective parts of our subject. Therefore it is necessary briefly to notice some of the results of the study of radiation.

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* A glaring example was the division of "Physics" into "Sound," "Light," "Heat," etc., for separate and isolated class and examination subjects.

THE STUDY OF RADIATION.

The construction of the ordinary spectroscope (Fig. 1) is well known, and it will not be necessary to describe its general mode of action here. When it is used with sunlight a band of light exhibiting variations of hue to the eye is seen in the eyepiece, or may be received on a screen placed in the focal plane of the telescope lens of the instrument. Visual observation is by no means the only way of studying the spectrum; a photographic plate may replace the screen, or again a slit in the screen made parallel to a monochromatic image of the collimator slit will transmit a narrow section of the spectrum which may thus be received on a delicate thermometer, such as a thermopile or bolometer, in order to measure its energy. Even with the ordinary spectroscope, in which the prism and lenses are of glass, it is found that energy is still transmitted by the slit in the screen when it is moved beyond the visible limits of the spectrum, more especially at the red end. The effect is increased by the use of such an apparatus as used by Paschen* and shown in Fig. 2, where the prism is made in fluor spar or rock salt and the lenses of the ordinary spectroscope are replaced by silvered concave mirrors. It is then found that the visible portion of the spectrum is only a narrow

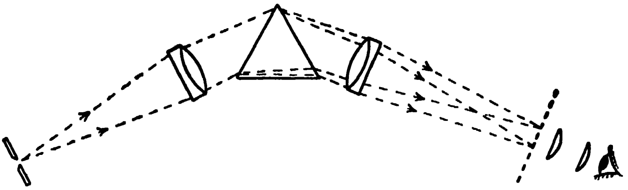

FIG. 1.

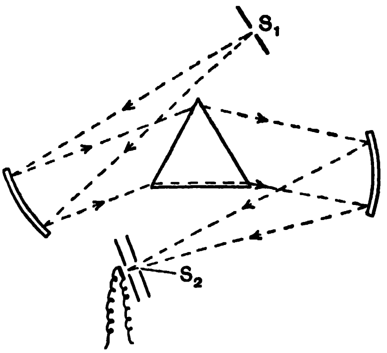

FIG. 2.

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* A useful list of Paschen's papers is given in Baly's Spectroscopy, 1912 edition, p. 272.

section of the whole radiation spectrum, as it is further possible with the aid of a suitable diffraction grating to determine the wave length of the radiations falling upon the thermometer.

It is thus possible to obtain a measure of the relative energy of different parts of the spectrum by moving the slit and thermometer through the whole range of it. No refracting prism will, however, give a spectrum in which the deviation is proportional to wave length, and hence the range of wave lengths found in the radiation transmitted by the slit s_2 will not be constant. If this range at wave length λ be denoted by $\delta\lambda$ and the corresponding energy as found by the thermometer be denoted by δE, then the energy per unit range of wave length at λ is given approximately by $\frac{\delta E}{\delta\lambda}$. Naturally the values of $\delta\lambda$ have to be determined by special methods, but when they have been found it is possible to plot a curve showing the relative energy per unit range of wave length (assuming a very small unit) at any position in the spectrum.

If the corrections to the experimental results are properly made, a curve of practically the same shape will always be obtained, no matter what apparatus for dispersion is employed, that is, of course, provided the original source of radiation and other conditions remain constant. Nevertheless, the result is not *quite* the one required on account of the necessary finite width of the two slits, the collimator slit and the thermometer slit, and a further correction may be necessary. This correction is usually of importance only if the energy curve happens to pass through a sharp maximum or minimum. When it has been made, the curve obtained will be almost exactly the one which would be obtained if by any means a superlatively sensitive thermometer could be used with vanishingly narrow slits. We shall thus obtain a curve which shows the characteristic relative energy distribution in the spectrum of the source, or in mathematical terms, the relation between the differential co-efficient $\frac{dE}{d\lambda}$ and the wave length itself. In expressions given below this differential co-efficient is simply denoted by E_λ.

If a number of different bodies are taken and heated to some common temperature well above that of their surroundings they manifest varying powers of radiation. As is well known, the best radiators are substances such as charcoal, which absorb radiation well when it falls upon them; the worst are those which reflect well, such as polished metal surfaces. The conception of the best radiator, the ideal "black body," which reflects no light, is, therefore, not difficult to form. Its nearest practical realisation is the small mouth of a box or chamber with a blackened interior, which, indeed, looks very black to the eye, and which, as a fuller discussion can easily show, approaches very nearly to the ideal. It can be made in porcelain or other material capable of withstanding high temperatures, and can be heated by an electrical furnace or other means. With the help of apparatus of this kind Lummer and Pringsheim* carried out their classical experiments on the distribution of energy in the spectrum of a "black body" at various temperatures. The character of the results is shown readily by Fig. 3. Not only does the total energy increase very rapidly at all wave lengths with rising temperature, but the maximum moves towards shorter wave lengths. In the diagram the position and extent of the visible spectrum is indicated.

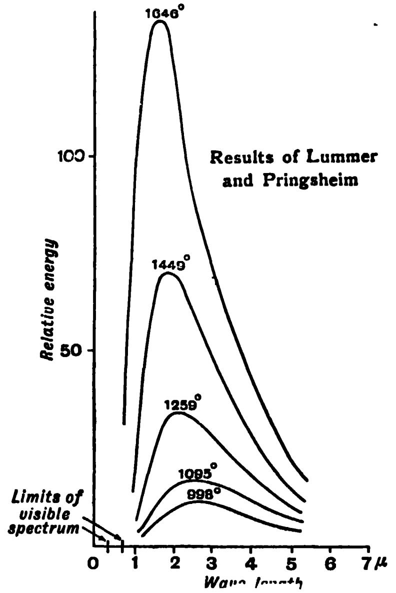

FIG. 3.

It will be noticed that in every case the energy falls rapidly towards the region of shorter wave length when the visible region is approached. Almost every practical source of artificial light consists of some body raised to incandescence, and consequently by far the larger proportion of energy is emitted in radiation incapable of causing a sensation of light, and finally becomes dissipated as heat. In practically every artificial illuminant the maximum energy of the spectrum lies well away from the visible region into the infra red, as is shown in Fig. 4.

In 1896 Wien† published his account of a theoretical investigation on thermodynamical principles which attacks the same problem as that dealt with experimentally (later) by Lummer and Pringsheim. Wein's expression, viz. :—$E_\lambda = c_1\lambda^{-5}e^{-\frac{c_2}{\lambda T}}$ where c_1 and c_2 are constants, λ is the wave length

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*Lummer and Pringsheim. Ann. der Phys. Bd 6, p. 192 (1901).

† Ann. d. Phys. Bd. 58, p. 662 (1896).

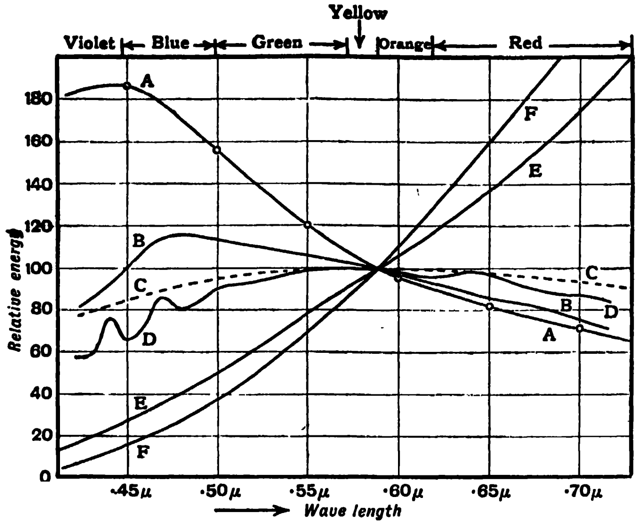

FIG. 4.—ENERGY DISTRIBUTION IN THE SPECTRA OF VARIOUS ILLUMINANTS.

A—Blue sky.
B—High sun (data from Smithsonian Instn.)
C—Ive's suggested standard (Black body at 5,000°).
D—Low sun (Smithsonian).
E—Gas filled tungsten lamp.
F—Acetylene flame.

and T is the absolute temperature, was found capable of representing the results of experiment satisfactorily in the regions of shorter wave length, but more recently an empirical expression was given by Planck*, which represents experiment through wider ranges. In modern literature a "black body" is often referred to as a "Planckian radiator." The main facts regarding the performance of a full radiator are thus well known, so that for example, if the energy curve of radiation for any source can be determined, its temperature can be calculated on the assumption that it radiates in accordance with Planck's law, which may be written

$$E_{\lambda} = c_1 \lambda^{-5}\left(e^{\frac{c_2}{\lambda T}} - 1\right)^{-1}$$

When λ is expressed in terms of μ, and T in terms of absolute temperature, c_2 is approximately 14350. Hence taking $\lambda = .5\mu$ (middle of spectrum) and $T = 5000°$ (sun), we see that we shall, therefore, make little error if we keep to the simple form of Wein's law. Generally speaking, in view of the probable experimental error in any practical experiments on energy distribution, we are amply justified in adopting Wein's law as amply accurate, provided that the discussion is confined to the visible spectrum.

One of the pioneers in the study of infra-red radiation was Professor S. P. Langley, who in 1881 invented the bolometer (a very delicate type of platinum resistance thermometer) for the purpose of investigating the infra-red spectrum of solar radiation.

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* Ann. d. Phys. Bd. 1, p. 69 (1900).

The results of Langley's work have been published in early volumes of the Annals of the Astrophysical Observatory, Washington. It was found that the infra-red spectrum contained many strong absorption bands, some of which could be traced to atmospheric absorption. By transporting the apparatus to the top of Mount Whitney, Langley was able to make an estimate of the atmospheric effect. Solar radiation has, however, many dark lines in the infra-red corresponding to the well-known Fraunhofer lines, in the visible spectrum.

Further work on the same lines has been carried out by Abbot*, of the Smithsonian Institution. The data thus obtained on the energy distribution in the visible portion of the spectrum have been examined by Priest†, who gives a curve representing the broad features of the mean energy distribution for noon sunlight. From this it appears that though sunlight does not follow strictly the law of Planck, it resembles approximately the radiation of a black body at an absolute temperature of 5,000°-5,300°. The wave length of maximum energy may be taken as .59μ sufficiently nearly.

Other observers have investigated the relative energy distribution in the spectra of other illuminants. For example Nichols‡ has compared the radiation from the sky under many conditions with that of an acetylene flame, using methods of visual spectrophotometry. If the energy distribution for such a flame be found (as has been done) the corresponding values for the sky radiation can be immediately calculated from Nichols' results. §Hyde, Ives, Cady and Luckiesh, working in the laboratory of the National Electric Lamp Association, have also examined the energy spectra of other illuminants, such as various electric and gas lamps. Curves and tables of their results are given in Luckiesh's book on "Colour."

Several energy distribution curves are given in Fig. 4 for blue sky, high and low sun, black body at 5,000°, gas-filled electric lamp, and acetylene. The physical characteristics of the types of radiation due to these sources are now fairly well known. It must still be remembered that, as shown by Nichols, daylight is a very variable quantity; when modified by transmission through fog or dust it may approach much more nearly to the distribution characteristics of artificial light, because of the scattering of the shorter wave length constituents. The results for high sun and low sun, shown in Fig. 4, are those due to Abbot (Smithsonian Institution). Ives suggested in 1910 that a standard of daylight should be the radiation of a black body at 5,000°

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* Ann. Astroph. Obs. Smithsonian Instn. Vol. 3, p. 135.

† Phys. Rev. Vol. 11, 1918, p. 504, and Scientific Papers Bur. of Standards, No. 417.

‡ Phys. Rev. Vols. XXVI. and XXVIII.

§ Jour. Franklin Inst., 1910, p. 439. Trans. Illuminating Eng. Society. America, 1910, p. 189. Trans. Illuminating Eng. Society. America, 1914, p. 839.

(maximum energy at about .59μ), but since a great deal of colour work in daylight is done (for preference) in rooms which receive much more blue sky light than sunlight it has been suggested by Dr. H. P. Gage* that an average "daylight" should be a compromise between blue sky light and sunlight, such as would be given (extrapolating from Planck's law) by a black body at a temperature of 6,500°-7,000°. Such a standard will, undoubtedly, represent closer approach to the north light considered desirable by artists, and the present writer, in dealing with the problem of selecting the best type of energy distribution for artificial daylight†, has always advocated the adoption of some such compromise.

SELECTIVE EFFECTS OF TRANSMISSION AND REFLECTION.

It is well known that "light" radiations can be modified by transmission or reflection through or from certain material substances, and further that such modifications most often arise by reason of the selective absorption of some of the wave length components of the original beam. In the present discussion we are concerned mainly with such actions as are manifest in the region of the visible spectrum. "Coloured" glasses are familiar objects, and their physical effect on radiation could be roughly investigated with the help of an apparatus such as that shown in Fig. 2, provided that two energy curves of some steady source were taken, first with the collimator slit free, second with the coloured glass supported in front of the slit normal to the entering light. In fact, physical methods of spectrophotometry‡ are finding an increasing usefulness, more especially the "null methods" in which photoelectric cells are employed. Visual methods are, however, much easier and in more common use. Whatever be the method, it will usually yield for a series of narrow spectral regions the ratio of the energy of the incident beam to that of the emergent beam, sometimes called the "opacity." Suitable corrections may be necessary for the effects of spectral impurity as mentioned above.§ The experimental results may thus be employed to find a curve expressing the opacity (or perhaps the percentage transmission) for the sample of coloured glass and its variation with wave length. Similarly, visual methods can be employed for the investigation of the selective effects of reflecting surfaces, although greater difficulties are encountered in such cases owing to the diffusion of the light. It gives direct readings in terms of "density" (that is the logarithm of the opacity) when used to determine the proportion of a light filter.

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* Sibley Jour. of Eng. 30, No. 8, May, 1916.

† Illuminating Engineer, Feb., 1920, Colour and Methods of Colour Reproduction, Blackie, 1923.

‡ Dictionary of Applied Physics, Vol. IV., p. 749.

§ A discussion of visual spectrophotometry and the necessary corrections is given in the author's book on Optical Measuring Instruments. Blackie, 1924.

ARTIFICIAL SUNLIGHT.

The simple nature of the curves expressing the energy distribution of illuminants in the visible region shows that the properties required of a light filter which is capable of correcting the excessive energy of the longer wave lengths in the case of most artificial lights are not of a complicated nature. That this is so appears at once from consideration of Wien's law, assuming that this is capable of representing the energy distribution for such cases, at least in the visible spectrum.

The energy of an artificial source at a temperature T_1 as modified by a light filter of opacity O_λ at wave length λ is given by—

$$\frac{E_{\lambda,\, T_1}}{O_\lambda} = \frac{c_1\lambda^{-5} e^{-\frac{c_2}{\lambda T_1}}}{O_\lambda}$$

The energy of another source at temperature T_2, the energy distribution of which it is desired to imitate, is given by—

$$E_{\lambda,\, T_2} = c_1\lambda^{-5} e^{-\frac{c_2}{\lambda T_2}}$$

In order that the energy distribution in the first case may be similar to that in the second, the ratio of the corresponding members of equations 2 and 1 must be constant, or independent of the wave length,

$$\therefore \quad \frac{e^{\frac{c_2}{\lambda T_2}}}{e^{\frac{c_2}{\lambda T_1}}} = \text{constant} \,.\, O_\lambda \,, \qquad \text{or, taking logs,}$$

$$\frac{c_2}{\lambda}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) = \text{const.} + \log O_\lambda \,,$$

but since the log of opacity is the density this gives:—

$$\text{density} = \frac{k_1}{\lambda} - k_2$$

(where k_1 and k_2 are new constants for a given T_1 and T_2), which shows that the density of a correcting filter must bear a simple appropriate linear relation to the reciprocal of the wave length, or to the frequency of the light. The required relative densities or transmission co-efficients can easily be calculated. It is usually found sufficient to give the correcting filter or reflector a maximum transmission or reflection at about .45μ. It should then conform to the correct law throughout the range of wave lengths longer than this. We shall return to this point.

SELECTIVE EFFECTS OF TRANSMITTING AND REFLECTING MATERIALS.

By far the greater number of the visual objects of ordinary experience retain very much the same hue under various conditions of lighting, and the physical explanation is naturally that in the majority of cases the selective effect is to give relative prominence to the energy of some local spectral region in the transmitted or reflected light, so that, provided the illuminant has a continuous spectrum, the appearances of a green book, a stick of yellow sulphur, and the like, remain fairly constant. The well known effects of visual fatigue enter also into the question. It has been shown that in artificial light the energy of the spectrum increases towards the longer wave lengths. Hence the colour fatigue of the retina will be correspondingly greater as the energy increases. Although an electric lamp appears very yellow in sunlight, a cloudy winter sky will seem very blue when seen in the late afternoon from the interior of a room brightly illuminated by the same lamp. The white table cloth in the same room still bears its characteristic " white " appearance. We are reminded of the principle of the constancy of the colours of material objects set forth by the psychologist Hering. This principle, however, is only a very rough approximation, and in many cases it breaks down altogether.

Many physical substances, especially dyes, show strong wide absorption bands in the central portions of the visible spectrum of the transmitted or reflected light. Their colour thus depends on a mixture of lights corresponding to separated spectral regions—a short wave region and a long wave region. Purple substances are typical examples. They show extremely great changes of hue when taken from sunlight into " blue sky light " or from daylight to artificial light, but there are many examples of grosser changes. Fig. 5 shows (curves for a and b) the reflection co-efficients throughout the spectrum of two dark blue fabrics. In daylight they match perfectly, but, owing to the increased relative energy of the longer wave lengths of artificial light, a appears a dark reddish purple in electric light, while b still appears blue, albeit much darker than in daylight.

The darkening effect on blues and greens can easily be observed experimentally. Artists know well the diminished capacity for colour perception caused by artificial illumination, athough gross colour changes are rare. As another example of a most striking change the fabric having the reflection curve c (Fig. 5) may be instanced. In daylight it is a decided moss green, but in artificial light it becomes brown. Just as in the case of a there is

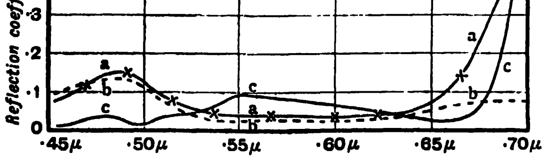

FIG. 5.

strong reflection in the extreme red, and consequently an excess of red energy from reflected artificial light. Such colours are known to the dyers as "sensitive tints."

It is surprising to realise the great number of commercial processes which depend largely on the accurate colour discrimination which demands daylight or corrected artificial light. The grading of many products, tea, tobacco, flour, and many other foodstuffs, paper, pigments, dyes, fabrics, and the like, is wholly or partly dependent on colour estimation. The drapery trades have already recognised the importance of correct lighting, and there are still fields for the application of adequately corrected illuminants in the lighting of public picture galleries. It seems absurd that such galleries should be closed at sunset, when so many of the general public have no time to visit them except during the evening.

SPECTROPHOTOMETRIC DATA.

It is not possible in the present lecture to deal with the methods and results of spectro-photometric examinations of transmitting and reflecting materials. Systematic quantitative work on the absorption of light by coloured glasses of definite composition has been done by Zsigmondy.* Abney† has examined the reflection co-efficients of many pigments. Uhler and Wood (1907), Jones and Anderson (1909), and Kenneth Mees (1909) have published useful atlases of absorption spectra which are chiefly useful from the qualitative standpoint. Messrs. Kodak, Ltd., publish a booklet giving numerical data and curves for their useful series of dyed gelatine light filters. Numerical data ‡ on "Spectral transmission of dyes" are being obtained by the Bureau of Standards, U.S.A., and some of the work has already been published in a paper which gives a good description of the experimental methods. The investigation of the spectral reflection of opaque materials is carried out most easily by Abney's colour patch apparatus, for a description of which, and also of the results of his work on pigments, reference may be made to the Cantor lectures on Light and Colour delivered by Abney in 1888. A description is also given in the present lecturer's book on "Colour."

ARTIFICIAL DAYLIGHT. EARLY ATTEMPTS AND MODERN DEVELOPMENTS.

In 1887 Hayward patented an invention for the improvement in the reflection of light by reflection of metal or silvered glass. When a "whiter description of light" than that given by gas or oil lamps is required he proposed the use of a tubular reflector covered at one end by a sheet of blue tinted glass. In 1892 A. P. Trotter§ suggested the use of selective light filters or reflectors for correcting the distribution of energy in the spectra of artificial light sources. In 1899 Dufton and Gardner brought out a screen for the correction of an arc light which employs a glass filter coloured blue green with copper. A trace of uranium in the glass absorbs the excess of violet light from the flame of the arc. They also mentioned, in the patent specification, the possible employment of a coloured reflector. Wood (1908) suggested the employment of filters of glass coated with resinate varnish, suitably coloured, for the correction of the light from ordinary metal filament electric lamps, and Mees, in 1910, produced a compound screen of two glasses with an intermediate dyed gelatine film for the same purpose. It had been found that neither " copper " nor " cobalt " glasses alone were entirely satisfactory. The use of dyed gelatine films is, however, not very advisable, mostly on account of their tendency to fade. Ives and Luckiesh, in 1911, produced a similar compound screen. The next attempt was in 1912, by R. B. Hussey, who used two glasses arranged in checker board fashion ; the transmitted light from an arc lamp was mixed by diffusing screens. In 1914 Luckiesh produced a glass for use with tungsten lamps, which aimed at improving, but not totally correcting the light. In the same year Ives and Brady produced satisfactory fully correcting glasses for use with Welsbach mantles and tungsten lamps, but this glass is not now obtainable to my knowledge. The war period naturally produced a lull in developments, but in 1919 the Corning Glass works brought out and patented a glass due to H. P. Gage, which has found wide commercial use in the Macbeth lamps. Glasses of this type usually have a lead potash basis with certain proportions of cobalt, manganese, nickel and copper (no doubt with other ingredients). Correction on an entirely different basis, recalling the earlier suggestions of Trotter and Dufton and Gardner, was suggested by G. Sheringham in 1919 as the results of independent experiment. This suggestion as brought to the present lecturer, was to employ a suitably coloured reflector in conjunction with a gas filled electric lamp, so that the excess of " cold " light from the reflector should compensate for the excess of red and yellow in the direct light from the lamps. It was found possible by exhaustive experiments carried out with the aid of A. Klein, to produce a lamp in which effective correction was secured by reflection of all the light of the lamp from a reflector coated with certain pigments distributed in small areas in certain determined proportions. The unit was manufactured and received the name of the Sheringham Daylight. Details are given in " Colour, and Methods of Colour Reproduction." Lamps with the bulb blown in blue-green glass were being placed on the market about this time. The correction given is by no means so drastic as with the north-light units, so that a greater efficiency in " light value " can be maintained.

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* Ann. d. Phys. 4.60 (1901). Zeit.f.Inst. 21.97 (1901).

† The Action of Light on Water Colours, H.M. Stationery Office, 1888.

‡ Scientific Papers (Bureau of Standards), No. 440.

§ Jour. Inst. Elec. Eng., Vol. XXI.

About this time Messrs. Chance Bros., of Birmingham, produced their Daylight Glass, which is employed alone in certain units for the correction of the light from gas-filled lamps. In order to keep up the luminosity of the transmitted light a slight excess of green transmission was tolerated by the manufacturers. Lamplough has found it possible to correct such an excess of green in the transmission of a glass by the use of gold as an ingredient in the glass, or by the use of supplementary filter of glass coloured to a light purple with gold. The principle is carried out in the Lamplough Day-lamp. Messrs. Kodak, Ltd., have also produced a lamp in which an improved screen due to Mees is employed.

The discussion of the effect of filters intended for the correction of artificial light can be greatly simplified by using the simple fact proved above, in that the density of the ideal correcting filter should bear a linear relation to the reciprocal of the wave length, under the assumption of "black body" radiation in all cases. From sources given above we extract the following table :—

RELATIVE ENERGY.

Wave Length. (μ)	Gas-filled lamp.	Blue Sky.	Gage's average daylight Black body at 7,000°.	Ive's average daylight Black body at 5,000°.
·45	30	187	129	84.3
·59	100	100	100	100

Let the density of the correcting filter for the gas filled lamp be zero at $.45\mu$, then for example, if t is the transmission factor at $.59\mu$ of this filter to correct "gas-filled lamp" energy distribution to "Ive's average daylight," we see that

$$\frac{t \times 100}{30} = \frac{100}{84{\cdot}3}$$

Hence the density required $= \log(1/t) = 0.449$. For correction to "Gage's average daylight" and "blue sky" the densities required would be .633 and .800 respectively. From the fuller tables given by Luckiesh and others the densities for a whole series of wave lengths can be thus derived, and the truth of the above theoretical law verified by plotting the density against the reciprocal of the wave length.

In Fig. 6 we erect ordinates at $\frac{1}{\lambda} = 1.695$, $(\lambda = .59\mu)$, of heights 0.449, 0.633, and 0.800. We join these points to the point of zero density at $\frac{1}{\lambda} = 2.22$, $(\lambda = .45\mu)$. These straight lines represent the properties of ideal filters to correct the light of a gas filled lamp to qualities of noon sunlight (Ives), mean of sunlight and blue sky (Gage), and blue sky light. An actual filter would still give a correct qualitative rendering if its density line or curve

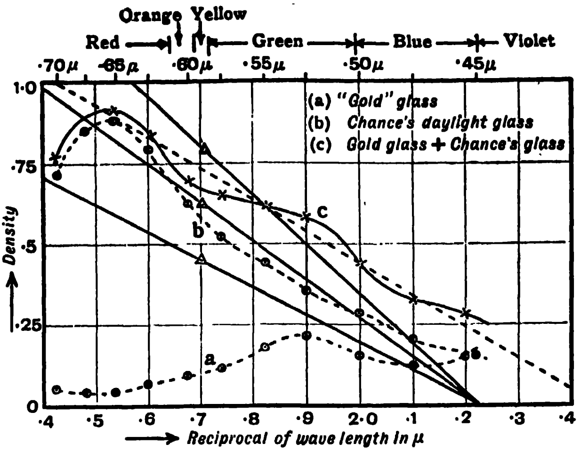

FIG. 6.

is uniformly displaced vertically above the ideal line, for the effect would be equivalent to two filters superimposed, viz. :—The ideal filter and one of uniform density (*i.e.*, a non-selective or neutral filter). The three points to be observed are thus :—

(1) The general slope (determining the type of correction).
(2) The regularity (determining the perfection of quality).
(3) The vertical displacement (determining the filter efficiency as compared with the best possible result).

In Fig. 6 are also plotted densities of Chance's daylight glass as obtained from spectro-photometer readings.* The general slope correspond to Gage's mean. The density is too low in the extreme red, and also slightly low in the green, as compared with the brighter parts of the ends of the spectrum. The density of a glass coloured with gold, such as used by Lamplough, is also shown, and the resulting density when this filter is superimposed on one of Chance's glass. The average type of correction is in this case rendered nearer to the "Ives" standard. The variations from the ideal straight line are in narrower regions than with the Chance's glass alone. These curves have considerable interest, as showing the possibilities of progress in any future experiments along these lines.

DEFECTS IN ARTIFICIAL DAYLIGHT.

Plotted in Fig. 7 is shown the visibility curve for the normal spectrum. This represents for any wave length the value of the fraction :—

$$\text{Visibility} = \frac{\text{relative luminosity as compared with white}}{\text{relative energy.}}$$

It will be seen at once why the gross departures from the sunlight curve shown in Fig. 7 at each end of the spectrum in the energy of the corrected

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* I am indebted for these results to Messrs. Chance, Bros., Ltd.

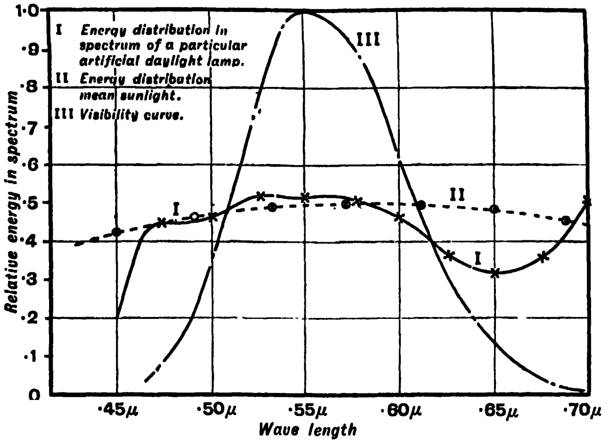

Fig. 7.

light do not procure a hopeless effect. The visibility of radiation at each end of the spectrum is extremely low, so that although an excess of " extreme red " energy and a deficiency of " extreme violet " is found (and, in fact, the same thing is found in all such lamps of which I have any knowledge), the eye cannot usually perceive the discrepancy or its effects when the light falls on coloured objects. Nevertheless, there are certain of the "sensitive tint" objects which are likely to exhibit more or less change when brought from " north sky " light to the corrected artificial light. Furthermore, the residual irregularities in the energy curve which also seem to be always inevitable are likely to produce slightly abnormal effect in special cases. It is of interest to note that with the reflector method (Sheringham daylight) it is possible to produce a smoother energy distribution than is the case with some of the " filter " units.

In spite of these minor difficulties the proper application of corrected lighting units has been found to be fairly satisfactory and efficient for most of the requirements of commerce and industry. Testimony is not wanting on that score. Where difficulty has been experienced it is usually the result of inadequate light intensity, which makes sensitive colour discrimination impossible. Where fine work must be done on a table or desk, a unit with an interior reflector of the focusing type should be employed. On the other hand, where accurately corrected light is required spread over a large area, a large thoroughly diffusing unit with a powerful lamp will be found of service. Care should be taken (actual measurements with a suitable brightness photometer, such as the Holophane Lumeter, are desirable) that the illumination on a table for colour matching or grading reaches a value of 2 to 4 foot candles at least. An increase even beyond this value will be a distinct advantage. Satisfactory diffusion of the light is very important, and when imitating daylight, the dimensions of the effective source ought to be as large as possible.

Recent work on colour vision* has revealed the fact that retinal reflex actions exercise an important influence in enhancing visual sensitiveness and discrimination, and some experiments by myself (unpublished at present) confirm this action. It appears that the reflex action is much greater at the violet than at the red end of the spectrum. Consequently the deficiency in the violet in artificial daylight may result in a relative diminution of retinal sensitiveness, and, therefore, a somewhat greater intensity than is necessary in the case of real daylight may be called for if the same facility in colour matching is to be obtained.

It will be realised that the great disadvantage of all the above methods of correction is the waste of a considerable amount of unwanted light—the excess energy of the longer wave lengths. For units giving a reasonably accurate correction a total light efficiency of 15 per cent. would be a good performance. Where only a partial correction is required efficiencies up to 60 per cent. can be realised. The absorbed energy is simply converted into heat by the filter or reflector. In view of the heavy charges for lighting power there would seem to be almost a case for placing the artificial daylight on the cheaper " heating energy " scale. But unless it is possible to perform the correction by some physical means radically different from those known at present, or to produce the light by other means, these losses are inevitable.

Of other possible means the Moore lamp (using an electric high tension discharge through rarefied carbon dioxide) has come nearest to providing a satisfactory artificial daylight, but the spectrum is not continuous, being banded. Hence the lamp is apt to fail for colour matching in special cases, although the light is a good subjective white. These high tension tubes must have a special installation, and apparently their use has not developed for these reasons.

LABORATORY METHODS OF CONTROL.

Although it is difficult to secure a glass correcting filter with a very regular transmission curve, the gelatine Wratten Filter No. 78 (Messrs. Kodak, Ltd., Wratten Division) supplies a useful substitute in cases where for photometric purposes it is desired to correct the light of a Tungsten lamp to a visual " daylight " quality. The transmission in sufficiently regular between about .45μ and .67μ. Full particulars are given in the Wratten Booklet.

We notice in passing that the colour filter may be used in the form of spectacles, if desired, and in this connexion patents by Grosheintz and Glasgow were taken out in 1914.

It is also possible to use physical means of correction other than light filters. The first may be explained as follows: Referring to Fig. 1 we imagine that in place of the eye-piece of the spectroscope we substitute a short focus telescope focused to view the back surface of the prism. The object glass of this telescope must be large enough to receive the whole of the visible spectrum as originally formed. Under these conditions the prism surface will be seen illuminated by light of the same quality as that entering the collimator. In the plane of the spectrum a rotating sector may now be introduced. Considering an ordinary sector as a light filter the density (*i.e.* $\log \frac{\text{incident light}}{\text{transmitted light}}$) will be $\log. \frac{360^\circ}{\text{total angular opening}}$.

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* **Frank Allen.** Journal Opt. Soc. America, 7., p. 583 (1923).

By using an opening of angular aperture which varies with the wave length transmitted at any radius, it will be seen that the angle will have to follow the simple law :—

$$\frac{k_1}{\lambda} + \log \alpha_\lambda = \text{const.}$$

(where α_λ is the angle of the opening corresponding to wave-length λ) when transforming black body radiation from the quality characteristic of one temperature to the quality of another. The necessary angles may, of course, be calculated from information already indicated regarding the energy distribution in the spectra of various sources. Corrections will probably be necessary on account of selective absorption in the instrument. Ives and Brady have used this method. With care, correction can also be given by a stationary opening of graduated width placed in the spectrum plane, but accuracy would not be so easy to obtain. The use of such rotating spectrum templates was suggested by Abney for other purposes in the Cantor Lectures of 1888.

Priest employs a different arrangement. A combination of two nicol prisms with a quartz plate of suitable thickness between them acts as a light filter* exhibiting selective spectral transmission by the action of the rotary dispersion of the quartz. The possible variation of the angular position of the analyser permits the adjustment of the energy distribution in the spectrum of the transmitted light. When used in conjunction with an artificial source of light, such as a tungsten gas-filled lamp, the constants of the apparatus can be so chosen that the distribution of energy in the transmitted light follows the law of Planck.

Priest defines the " Colour temperature " of a source as the temperature at which a hypothetical Planckian radiator (" black body ") would emit light competent to evoke a colour of the same quality (hue and saturation) as the light from the lamp under test. By the above means he has investigated the colour temperatures of various artificial sources, and has also determined the approximate spectral distribution of energy which evokes a visual sensation devoid of hue, assuming that as the temperature rises the hue of the light passes from a warm to a cold quality through a pure grey or white. The effect of temperature variation is imitated by the rotary dispersion method. From the results of this work Priest suggests that the standard of artificial daylight should be the radiation of a black body at a temperature of 5,200° imitated by the above rotary dispersion arrangement.

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* Jour. Opt. Soc. Amer. 4 pp. 485-486.

P. R. Ord (Messrs. Adam Hilger, Ltd.) has carried out a series of spectrophotometric experiments giving the relative variations of "red," "green," and "blue" energy in the spectrum of North Sky light. The ratio of green to red varied between 31 per cent. and --25 per cent. on various days, while the corresponding variation of blue to red was between 45 per cent. and —25 per cent.

Direct comparisons between an artificial daylight lamp and "north sky" light were also made with the aid of the Hilger Nutting spectrophotometer. The results showed that the lamp was not fully corrected to north sky quality, but it would have appeared considerably better had the comparison been made with sunlight. The experimental method is of considerable interest, but in view of the difficulties encountered it would probably be more satisfactory to make the comparison of such lamps with precision artificial daylight produced either by the template or rotary dispersion method rather than with the highly variable daylight itself. The spectrum of sky light is apt to show certain local irregularities depending on the surroundings. In the country chlorophyll bands may be detected, and in large towns it would not be surprising to find other types of variation.

EFFECTS OF ADAPTATION.

One of the psychological factors against the use of artificial daylight is the cold quality of the light as compared with ordinary artificial light, and, indeed, it should not be forgotten that when one shop window in twenty uses artificial daylight at night the general appearance will be judged by eyes accustomed to the ordinary illuminants, with the result that even a slight correction seems very much more drastic. If I were a shopkeeper I should not tolerate a lamp bulb giving (as so many do) an apparently greenish appearance to the general effect. For accurate colour matching the eyes must be given time properly to adapt themselves to the light from the fully corrected units, and this probably requires several minutes. The requirements for window lighting are thus totally different from those for producing the normal daylight effect.

DR. MANN JUVENILE LECTURE.

The fourth series of Juvenile Lectures under the Dr. Mann Trust was commenced on Wednesday afternoon, January 7th, by LIEUT.-COLONEL E. H. RICHARDSON, the subject being "Dogs in War." The chair was taken by LORD ASKWITH, K.C.B., K.C., D.C.L., late Chairman of the Council.

In introducing the lecturer, LORD ASKWITH mentioned that under the terms of the will of the widow of Dr. Robert James Mann a sum of money was bequeathed to the Society to provide for "two or more lectures for the instruction of a juvenile audience," in commemoration of her husband, and that Colonel Richardson's course was the fourth of this series. Dr. Mann, who was born at Norwich in 1817, resided from 1857 to 1866 in Natal. He returned to this country, and from 1874 to 1886 acted as Secretary to the African Section (now the Dominions and Colonies Section) of the Society. He took a great interest in the work of the Society and read numerous papers before it, mainly on subjects connected with Africa. His death occurred in 1886, and Mrs. Mann died in 1920. Colonel Richardson had devoted his life to the study and training of dogs, and, knowing this, the authorities, at the outbreak of the Great War, requisitioned his services for the training of dogs for military and other purposes.

COLONEL RICHARDSON said he had been asked to talk about dogs and to give some idea of the extraordinary amount of useful work which could be accomplished by them in different capacities. Most of those in the audience, no doubt, kept dogs, and, therefore, knew how much pleasure and amusement they could give us; and perhaps also they had realised how useful dogs might be to man if their remarkable intelligence was directed along practical lines. The subject of war dogs came into great prominence during the war. The fact that dogs could prove useful in warfare had for many years before this been recognised. As a matter of fact, dogs were used in warfare from ancient times, and the armies of the Greeks and Romans found them an important aid in their battles. He began to train dogs for military purposes thirty years ago, and had continued the work ever since. In his pioneer efforts he had met with a great deal of prejudice and indifference, owing to mistaken ideas as to the methods of training. There was nothing cruel in the training; indeed, the most remarkable feature was the joyous co-operation between dog and man whenever its help was asked for. Like human beings, dogs were much happier in having some definite work to do, but the work must, of course, be within their capacity. The training rested on the affection and companionship between master and dog. Rough treatment totally spoiled that relationship, and dogs could not be trained on such lines.

A long and interesting series of lantern slides followed. These showed dogs employed by the Russians during the Russo-Japanese War; bloodhounds used with the Spanish forces in Morocco; ambulance dogs used for locating the wounded on battlefields and guiding stretcher-bearers to them; messenger dogs employed in carrying messages, plans, etc., between various bodies of troops; and dogs acting as sentries, guarding powder magazines and other vulnerable posts.

In August, 1914, before the entry of the German troops, Colonel Richardson was on his way to Brussels, with some dogs intended to be used for ambulance purposes. It was, however, found that dogs were unsuitable for this

COLONEL RICHARDSON AND THREE OF HIS WAR DOGS.

work on the Western front owing to the stationary nature of the warfare there; but they were employed for Red Cross duties on the Polish frontier. Sentry dogs and messenger dogs were much needed, and he was asked by the War Office to organise a training school for sentry dogs. He outlined the methods of training and exhibited slides depicting the dogs at work. The types of dogs trained at the War Dog School at Shoeburyness ranged from a great St. Bernard to small cross-bred collies and lurchers. Nothing but British breeds were used in the British Army. The dogs were largely recruited from Lost Dog Homes in London and the provinces, numerous dogs being also sent to the training school from all parts of the country by private owners. One of the illustrations was that of a widow, whose husband and son were both killed in the war, bringing in her lost son's Airedale terrier to be trained at the school—the last thing she could do for her country. Mr. Holmes, the well-known American photographer, happened to be visiting the school at the time, and he snapshotted the incident. The picture was exhibited in many parts of America, and was said to have helped to break down in the United States any doubts our friends might have had as to the staying power and determination of Great Britain to fight the war to the finish.

Sentry dogs were badly wanted for mounting guard, and Airedales were largely used for this class of work. The training took place mostly at night, for dogs worked a great deal better in the dark than by daylight, as their senses were then much more acute. Messenger dogs during their training were accustomed to work over very rough ground similar to that in the war zone, so that they could traverse quickly country impossible or exceedingly difficult for men. They were trained to leap obstacles, swim streams, and bring messages through a fusillade of blank rifle fire as well as smoke screens, and accustomed to the sounds of shell fire and bombing. All these exercises had to be done voluntarily by the dog, who would carry vital messages across two and three miles of unknown country. Love for its master and the desire to rejoin him were the dog's great incentive, which led him to face every kind of danger and difficulty.

Colonel Richardson quoted official reports on some of the remarkable exploits of different war dogs, who on occasions had carried important messages, traversed country quite unknown to them, passed through gas and smoke, barrages of gunfire and masses of troops, and brought in messages when all other means of communication had failed. The collie dog "Roman" had carried a message a distance of 3½ miles from an infantry regiment in need of ammunition and entirely cut off. "Little Jim" had a remarkable gift of scent and was able to detect the approach of gas long before any one else. He never failed to give warning. He was a most reliable dog, and his speed in carrying messages was three or four times that of a runner. The lurcher dog "Creamy" was attached to the Black Watch Regiment. He had brought a map through in 25 minutes—a task which would have taken a runner from 2½ to 3 hours. The dog had only been at the front one night before being called upon to perform the duty. An old English sheep dog, " Tweed," brought a message through a fierce barrage and enabled troops to be rushed to the spot to relieve a serious situation. The dog and its keeper were devoted to one another and now they were both in Canada. The report on " Trick " stated that whenever a message of urgency and importance was to be forwarded, he was immediately sent for and he had never proved untrustworthy. " Maggie " had brought in a very important message although dangerously wounded. After brilliant service this dog had laid down her life on the field of battle, and it was impossible to estimate the number of lives saved by her alone. Colonel Richardson added that he had only touched upon the many brave deeds of these war dogs.

At the conclusion of the lecture, Colonel Richardson introduced to the audience " Tom," a battle-hero, who had done some wonderful work in France, and three Airedales under training as war-dogs.

THE SWINEY CUP.

On page 217 is given an illustration of the Swiney Cup, which was awarded this year to Sir Paul Vinogradoff, D.C.L., LL.D., F.B.A., Corpus Professor of Jurisprudence in the University of Oxford, for his work, " Outlines of Historical Jurisprudence."

The Swiney Prize was founded in 1844 by Dr. George Swiney, who bequeathed the sum of £5,000 Consols to the Society of Arts for the purpose of presenting a prize, on every fifth anniversary of his death, to the author of the best published work on Jurisprudence. The prize is a cup of the value of £100, and money to the same amount.

The cup presented this year is the work of Mr. Charles Welch, of the L.C.C. Central School of Arts and Crafts, and is a fine specimen of hand-made silversmith's work. The body, base of foot, and cover are shaped with ten flat sides. The base of the foot has a panel of hand-pierced ornament. The stem of the foot is circular in shape, and the knop is enriched with a band of engraved ornament. The design of the knob on the cover is adapted from the Society's seal, and shows the Serpent of Wisdom encircling the world. The height of the cup is eighteen inches.

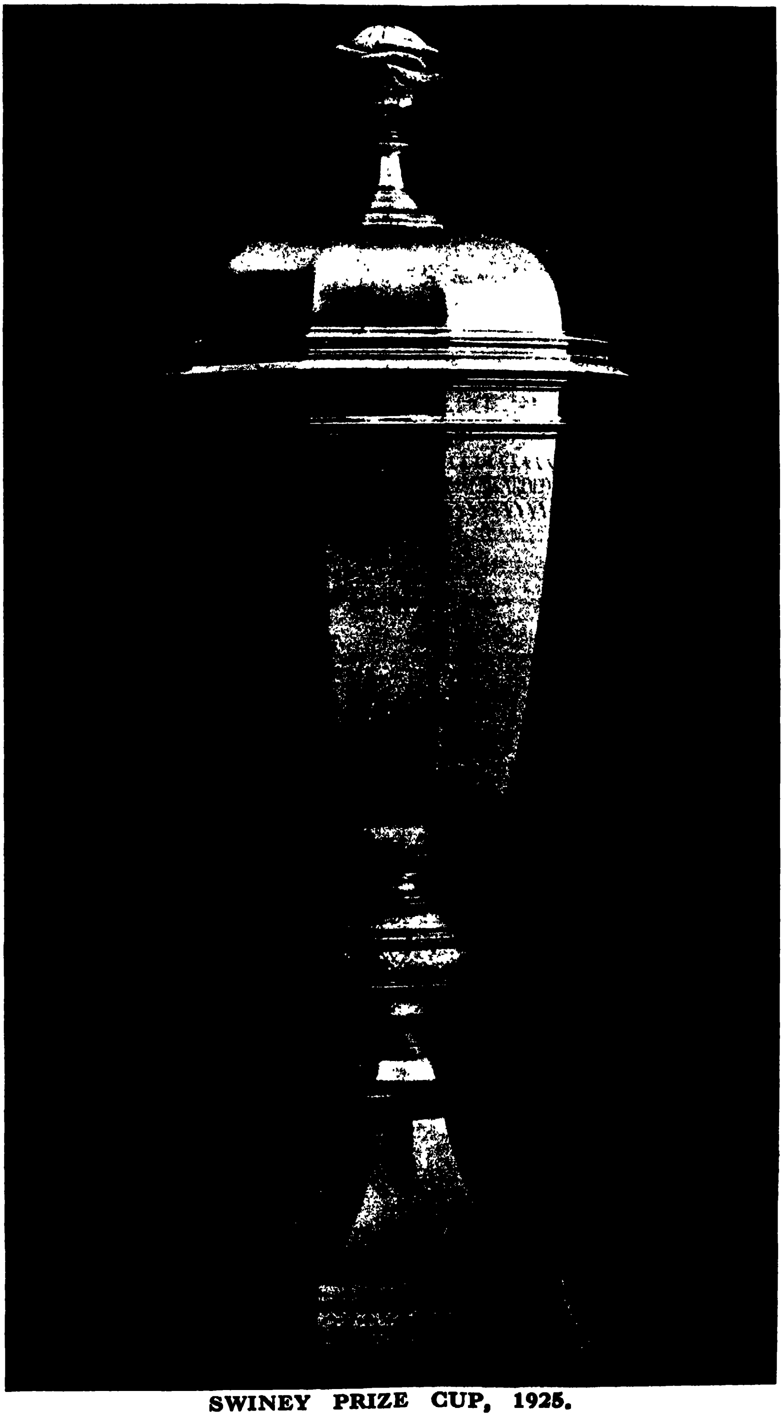
MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock, unless otherwise announced :—

JANUARY 21.—MRS. GRAYDON-STANNUS, " Irish Glass, Old and New." SIR HERBERT JACKSON, K.B.E., F.R.S., will preside. Specimens of the glass will be exhibited.

JANUARY 28.—CHARLES A. BAKER, M.I.E.E., Assistant Engineer, London County Council, " The Electrical Equipment of the London County Hall." SIR GEORGE HOPWOOD HUME, M.P., Alderman, London County Council, will preside.



SWINEY PRIZE CUP, 1925.

FEBRUARY 4.—SIR ERNEST RUTHERFORD, O.M., M.A., D.Sc., F.R.S., *Trueman Wood Lecture*, " The Stability of Atoms." SENATORE GUGLIELMO MARCONI, G.C.V.O., LL.D., D.Sc., Chairman of the Council, will preside.

FEBRUARY 11 (at 4.30 p.m.).—SIR J. FORTESCUE FLANNERY, Bt., Past-President of the Institute of Marine Engineers, " The Diesel Engine in Navigation." LORD BEARSTED, LL.D., will preside.

FEBRUARY 18.—J. S. OWENS, M.D., Assoc.M.Inst.C.E., F.G.S., Superintendent Advisory Committee on Atmospheric Pollution, Air Ministry, Meteorological Office, " Modern Atmospheric Conditions." SIR NAPIER SHAW LL.D., Sc.D., F.R.S., will preside.

FEBRUARY 25.—SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., " The Power of Internal Combustion Engines for Motor Cars." THE HON. SIR CHARLES A. PARSONS, K.C.B., LL.D., D.Sc., F.R.S., will preside.

MARCH 4.—PROFESSOR W. E. S. TURNER, O.B.E., D.Sc., F.Inst.P., Department of Glass Technology, University of Sheffield, " The Modern Production of Sheet-Glass."

MARCH 11.—EMILE CAMMAERTS, " The Restoration of Public Buildings in Belgium." VISCOUNT BURNHAM, C.H., LL.D., will preside.

MARCH 18.—CLAUDE N. FRIESE-GREENE, " Colour Cinematography."

MARCH 25.—HENRY G. DOWLING, " Wall-papers."

APRIL 1.—WILLIAM NUNN, "Siam."

Dates to be hereafter announced:—

MAJOR-GENERAL SIR WILLIAM SEFTON BRANCKER, K.C.B., Director of Civil Aviation, Air Ministry, " Commercial Aviation."

CEDRIC CHIVERS, " Bookbinding."

C. R. PEERS, C.B.E., F.S.A., Chief Inspector of Ancient Monuments and Historic Buildings, " The Development of Ornament."

LIEUT.-COLONEL ANDREW BALFOUR, C.B., C.M.G., M.D. (Edin.), B.Sc. D.P.H., F.R.C.P.E., " The Trend of Modern Hygiene."

DAVID GREENHILL, " Colour Printing."

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock:—

FEBRUARY 6.—J. T. MARTEN, M.A., I.C.S., " The Indian Census." SIR EDWARD ALBERT GAIT, K.C.S.I., C.I.E., Ph.D., will preside.

MARCH 6.—SIR HENRY SHARP, C.S.I., C.I.E., M.A., " The Development of Indian Universities."

MAY 8.—SIR GILBERT T. WALKER, C.S.I., M.A., F.R.A.S., Sc.D., Ph.D., F.R.S., " Indian Meteorology."

JUNE 12.—BRIGADIER-GENERAL SIR PERCY M. SYKES, K.C.I.E., C.B., C.M.G., " The Heart of Asia and the Roof of the World."

Date to be hereafter announced:—

SIR ALFRED CHATTERTON, C.I.E., Assoc.M.Inst.C.E., "The Industries of the Mysore State."

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons, at 4.30 o'clock, unless otherwise announced:—

JANUARY 27.—WALTER RANALD DUNLOP (late Professor of Economics, Imperial College of Tropical Agriculture), "Economic Research in Tropical Development." SIR HALFORD J. MACKINDER will preside.

FEBRUARY 24.—R. H. BRACKENBURY, Member of the Empire Cotton Growing Corporation Mechanical Transport Sub-Committee, "Transport in Tropical Africa."

JUNE 18 (Thursday).—HON. W. G. A. ORMSBY-GORE, M.P., Under Secretary of State for the Colonies, "East Africa."

Dates to be hereafter announced:—

LORD BLYTH, "Penny Postage and Postal Communications Generally."

DOMINIONS AND COLONIES AND INDIAN SECTIONS. (JOINT MEETING).

Date to be hereafter announced:—

LORD STEVENSON, G.C.M.G. (Chairman, Standing Committee of British Empire Exhibition), "The British Empire Exhibition." SIR CHARLES CAMPBELL MCLEOD, Bt. (Chairman of the Finance Committee of the Exhibition) will preside.

CANTOR LECTURES.

Monday evenings, at 8 o'clock:—

V. E. PULLIN, Director, Radiological Research Department, Woolwich, "Radiological Research—A History."

LECTURE I.—JANUARY 19.—Natural Philosophy. The fascination of speculative philosophy. The border line between science and philosophy. Early natural philosophy. Development of theory. Discovery of X-rays. Controversy as to their nature. Modern theory concerning X-rays. Relation to modern atomic theory.

LECTURE II.—JANUARY 26TH.—Early apparatus. Early X-ray generators. Early vacuum tubes. X-ray tubes. Development of electrical generators. Development of X-ray tubes. The X-ray spectrometer. Measuring apparatus. Lines of modern radiological research.

LECTURE III.—FEBRUARY 2.—Early applications of X-rays. Development of medical uses. Modern applications. Physiological dangers. Necessity for protection.

WALTER ROSENHAIN, B.A., B.C.E., D.Sc., F.R.S., Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory, "The Inner Structure of Alloys." Three Lectures. February 16, 23, March 2.

HOWARD LECTURES.

Monday evenings, at 8 o'clock:—

PROFESSOR JOHN SAMUEL STRAFFORD BRAME, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, "Motor Fuels." Three Lectures. April 20, 27, May 4.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, JANUARY 19..Victoria Institute, Central Buildings, Westminster, S.W. 4.30 p.m. Dr. Dorothy M. Wrinch, "Seismic Phenomena."

Automobile Engineers, Institution of (Local Centre), Royal Technical College, Glasgow. 7.30 p.m. Mr. C. Macbeth, "Low Pressure Pneumatic Tyres."

Mechanical Engineers, Institution of (Graduates' Section), Storey's Gate, Westminster, S.W. 7 p.m. Mr. A. J. D. Humby, "Turbo-Blowers."

Electrical Engineers, Institution of (Local Centre), The University, Liverpool. 7.30 p.m. Sir Oliver J. Lodge, "The Nature of Electricity."

British Architects, Royal Institute of, 9, Conduit Street, W. 8 p.m. Dr. O. Faber, "Applications in Building and Foundations of Modern Engineering Construction."

Geographical Society, Kensington Gore, S.W. 5 p.m. Mr. C. S. Wright, "The Origin and Movements of the Ross Barrier."

London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. Dr. E. B. Behrens, "International Problems of Industry." (Lecture I.)

East India Association, Caxton Hall, Westminster, S.W. 3.30 p.m. Prof. J. W. Scott, "Unemployment—A Lead from India: the Calcutta Educational Colonics Movement and its Principle."

TUESDAY, JANUARY 20..Statistical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 5.15 p.m. Mr. R. J. Thompson, "An Agricultural Census."

Automobile Engineers, Institution of (Local Centre), The Engineers' Club, Wolverhampton. 7.30 p.m. Mr. C. Macbeth, "Low Pressure Pneumatic Tyres."

Electrical Engineers, Institution of (North Western Centre), at the Engineers' Club, Albert Square, Manchester. 7. p.m. Mr. H. W. Taylor, "Three-Wire Direct-Current Distribution Networks. Some Comparison in Cost and Operation."

(Scottish Centre), 39, Elmbank Crescent, Glasgow. 7.30 p.m. Miss Kennedy, "Electric Cooking."

(East Midland Sub-Centre), at the Technical College, Derby. 6.45 p.m. Mr. C. Beaver, "Some Points in the Manufacture and Installation of High Voltage Cables."

Marine Engineers, Institute of, 85, The Minories, E. 6.30 p.m. Eng.-Lieut. A. Marsden, "Oil Burning in Steam Generators and Furnaces."

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. A. Fowler, "The Analysis of Spectra." (Lecture II.)

WEDNESDAY, JANUARY 21..United Service Institution, Whitehall, S.W. 3 p.m. Major K. B. Ferguson, "The Situation in the Pacific."

Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

Meteorological Society, 49, Cromwell Road, S.W. 7.30 p.m. Annual General Meeting.

Microscopical Society, 20, Hanover Square, W. 8 p.m. Annual Meeting. Presidential Address by Mr. A. C. Chapman, "The Yeasts: a Chapter in Microscopical Science."

Design and Industries' Association, at the London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. Mr. W. H. Ansell, "The Principles of Design as Applied to Buildings."

Electrical Engineers, Institution of (Local Sub-Centre), Royal Victoria Hotel, Sheffield. 7.30 p.m. Mr. W. E. Burnand, "Inventions and Patents."

University of London, University College, Gower Street, W.C. 6 p.m. Mr. H. Higgs, "The Financial Problems of Europe." (Lecture I.)

THURSDAY, JANUARY 22..Royal Society, Burlington House, Piccadilly, W. 4 30 p m

Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p m

Royal Institution, Albemarle Street, W. 5.15 p.m. Mr. J. S. Huxley, "The Courtship of Animals and its Biological Bearings" (Lecture II)

Linnean Society, Burlington House, Piccadilly, W. 5 p.m. The President and Mr. R. D'O. Good, "The Recent Meeting in Canada of the British Association"

Victoria and Albert Museum, South Kensington, S.W. 6 p.m. Mr. B. Rackham, "English Pottery"

Textile Institute, 38, Bloomsbury Square, W.C. 7 p.m. (Informal Meeting). Mr S. A. Welch, "Celanese Yarn"

Aeronautical Society, 7, Albemarle Street, W. 5.30 p.m. Major R. V. Southwell, "Some Recent Work of the Aerodynamics Department, National Physical Laboratory"

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. Mr. H. W. Clothier, "The Design of Electrical Plant, Control Gear and Connections for Protection against Shock, Fire and Faults"

Electrical Manufacturers' Association, 15, Savoy Street, Strand, W.C. 4.30 p.m. Mr. W. E. Bush, "The Importance of Good Lighting to the Electrical Engineer."

Auctioneers' and Estate Agents' Institute, 29, Lincoln's Inn Fields, W.C. 7.30 p.m. (Junior Members' Meeting). Mr. A. L. Mann, "Town and Suburban Property Management."

FRIDAY, JANUARY 23..Engineering Inspection, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 7.45 p.m. Mr. S. D. Summerfield, "Advantages of Inspection through the Buyer."

Royal Institution, Albemarle Street, W. 9 p.m. Dr. A. W. Crossley, "Science and the Cotton Industry."

Engineers, Junior Institution of, 39, Victoria Street, S.W. 7.30 p.m. Mr. R. H. Parsons, "Boiler-House Records and their Practical Value."

Aeronautical Engineers, Institution of, at the Engineers' Club, Coventry Street, W. 6.30 p.m. Lieut. N. A. Olechnovitch, "A Few Experiments with Shock-Absorbing Hulls for Flying Boats."

Constructive Birth Control and Racial Progress, Essex Hall, Essex Street, W.C. 8 p.m. Prof. A. M. Carr-Saunders, "The History of the Limitation of Numbers."

SATURDAY, JANUARY 24..Royal Institution, Albemarle Street, W. 3 p.m. Prof. G. Gordon, "Shakespeare and the Spirit of Comedy."

London County Council, at the Horniman Museum, Forest Hill, S.E. 3.30 p.m. Mr. W. J. Perry, "Rough Stone Monuments and their Builders."

JOURNAL OF THE ROYAL SOCIETY OF ARTS

No 3766 VOL. LXXIII.

FRIDAY, JANUARY 23, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, JANUARY 26TH, at 8 p.m. (Cantor Lecture.) V. E. PULLIN, Director, Radiological Research Department, Woolwich, "Radiological Research—A History." (Lecture-II)

TUESDAY, JANUARY 27TH, at 4.30 p.m. (Dominions and Colonies Section.) WALTER RANALD DUNLOP, late Professor of Economics, Imperial College of Tropical Agriculture. SIR HALFORD JOHN MACKINDER, M.A., will preside. Tea and coffee will be served in the Library at 3.45 p.m.

WEDNESDAY, JANUARY 28TH, at 8 p.m. (Ordinary Meeting.) CHARLES A. BAKER, M.I.E.E., Assistant Engineer, London County Council, "The Electrical Equipment of the London County Hall." SIR GEORGE HOPWOOD HUME, M.P., will preside.

COUNCIL.

A meeting of the COUNCIL was held on MONDAY, JANUARY 12th. Present:—LORD ASKWITH, K.C.B., K.C., D.C.L., in the Chair; CAPTAIN SIR ACTON BLAKE, K.C.M.G., K.C.V.O.; SIR WILLIAM HENRY DAVISON, K.B.E., D.L., M.P.; SIR ROBERT HADFIELD, Bt., D.Sc., D.Met., F.R.S.; REAR-ADMIRAL JAMES DE COURCY HAMILTON, M.V.O.; MAJOR SIR HUMPHREY LEGGETT, D.S.O., R.E.; MR. ALAN A. CAMPBELL SWINTON, F.R.S.; DR. J. AUGUSTUS VOELCKER, M.A.; and SIR FRANK WARNER, K.B.E., with MR. G. K. MENZIES, M.A. (Secretary of the Society) and MR. S. DIGBY, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

LORD BEARSTED, LL.D., was appointed a Vice-President of the Society in place of Mr. JOHN SLATER, deceased.

SIR ALFRED YARROW was appointed a Trustee of the Soane Museum.

The arrangements for the Trueman Wood Lecture on Wednesday, February 4th, were reported.

The particulars of the Competition of Industrial Designs, 1925, were laid on the Table.

An Interim Report from the Thomas Gray Memorial Trust Committee was approved. [For further particulars of this Trust see page 241].

A letter from the Merchants' Association of New York was considered. [See Note on page 245].

Other formal business was transacted.

INDIAN SECTION COMMITTEE.

The Council have appointed Sir Atul Chandra Chatterjee, K.C.I.E., I.C.S., High Commissioner for India, a member of the Committee of the Indian Section. He read a paper before the Society in 1917 on "Development of Banking and Thrift in India."

TEN-VOLUME INDEX TO "JOURNAL."

The amalgamated Index to the *Journal of the Royal Society of Arts* for Vols. LXI.-LXX. (1912-1922) is now ready, and can be obtained free by Fellows of the Society on application to the Secretary, Royal Society of Arts, John Street, Adelphi, London, W.C. The price to non-Fellows is 2*s.* 6*d.*

PROCEEDINGS OF THE SOCIETY.

◆

CANTOR LECTURES.

MODERN COLOUR PROBLEMS.

By Louis C. Martin, D.Sc., A.R.C.S., D.I.C., F.R.A.S.,

Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and Technology.

Lecture II.—*Delivered December 1st,* 1924.

THE PSYCHO-PHYSICAL BASIS OF COLOUR MEASUREMENT.

In the Cantor Lectures of 1888, Abney referred to the "measurement of colours in terms of a standard;" he was referring to the determination of the reflecting powers, throughout the spectrum, of physical substances. Such measurements, as was shown in the previous lecture of the present series, can be carried out by physical means, and the results for any substance represent definite physical properties of the body which are unaltered when the illumination of the body is allowed to vary. But, as we have already seen, the apparent hue of certain materials alters radically with changes of illumination, and, moreover, the apparent hue of a selectively transmitting substance, such as a solution of potassium dichromate, alters with the thickness through which light is transmitted (Dichromatism). Clearly, then, it is necessary to abandon Hering's principle of the colour constancy of visual objects as a rigid principle. We recognise that the type of radiation illuminating the object, and the spectral reflecting or transmitting powers of the substance, together determine the energy distribution of the radiation reaching the retinal image. The mental *sensation* is called forth by the energy *stimulus*. Nothing is easier, however, than to show that the same sensation may not always follow the same stimulus. It is only necessary to gaze fixedly at a bright red light for a few moments to bring the eyes into such a condition that an (ordinarily) yellow light appears quite green. The psychologist who studies mental phenomena must, therefore, differentiate clearly between the sensation and the energy stimulus.

In spite of the apparent complexity of these considerations (which complexity is greatly increased by considerations of the physiological action of the retino-cerebral receiving apparatus) the principle of the colour constancy of visual objects is sufficiently accurate under ordinary conditions to make a demand for some means of specifying the colour of an object in terms of a few symbols which cannot be misunderstood, as is easily possible in the case of the multitudinous arbitrary names which are found in a modern draper's catalogue. It requires little imagination to realise the field of usefulness for such a nomenclature or notation. In the future we may imagine a South American merchant wishing to place in Great Britain an order for a fabric of an unfamiliar colour of which he possesses a sample. He will have available an instrument which gives him the colour in some international code 62X, 4Y, 3Z (say). He will *telegraph* the order or request for trial pieces with the certainty of obtaining what he wants, and will not have to wait while his sample is transmitted by post. If such a system can be made available, its importance to Great Britain, with our great textile and chemical industries, is extremely great. This subject of colour measurement has, therefore, a very practical interest and is by no means confined to an academic discussion of the subject of colour vision, interesting as that may be. We shall examine the variation of colour sensations in order to investigate the possibility of evoking them by the application of physical stimuli which can be analysed in simple terms. It will be necessary for the present to regard the visual receiving apparatus as acting normally in all cases.

COLOUR PERCEPTION.

An introspective examination of the elements of colour perception results in the separation of three outstanding characteristics, which are usually referred to as brightness, hue, and saturation. The general ideas of " brightness " and " hue " are sufficiently well known in a conversational sense, but the word " brightness " is sometimes given a technical meaning in photometry.

A Committee of the American Optical Society* reporting on Colorimetry suggested the term " brilliance " to denote the attribute of visual sensation commonly known as brightness. Definitions were given as follows :—

(*a*) Brilliance is that attribute of any colour in respect of which it may be classed as equivalent to some member of a series of greys ranging between black and white.

(*b*) Hue is that attribute of certain colours in respect of which they differ characteristically from the grey of the same brilliance and which permits them to be classed as reddish, yellowish, greenish or bluish.

(*c*) Saturation is that attribute of colours possessing a hue which determines their degree of difference from a grey of the same brilliance.

Exception is taken in the report to the application of the above terms to denote properties of the normal corresponding stimulus; for example, it is considered illegitimate to refer to brilliance or saturation as a property of light, or to measure these things by reference to *any* kind of photometric scale in the corresponding stimulus.

Terms like " distance," however, are used freely in either the psychological or physical sense, and it does not seem obvious why reservations of the above nature are considered to be vital.

The introspective approach necessarily sets up words like " white," " grey " and the like, but for purposes of colorimetric theory and measurement this is too indefinite. Adopting the physical standpoint we may recognise " brightness " as the attribute of sensation which varies with the energy of the stimulating light (other things being constant). " Grey " is the quality of the sensation evoked by radiation in which the spectral energy distribution is similar to that in the spectrum of a black body at 5,000° absolute. " Saturation " is the attribute of sensation which in general diminishes when light of a colour other than grey is " diluted " with grey light. " Hue " is, in general, produced in the sensations evoked by light for which the spectral energy distribution differs from that characteristic of a grey light; colour sensations are distinguished by their hues in the absence of differences of brightness and saturation.

Considerable discussion is taking place at the present time regarding the differentiation of terms applied respectively to sensation and stimulus. Since the underlying mental concept associated with a term like " brightness " is the same in each case, why should not the differentiation be made with an appropriate adjective? It would be possible to speak of " sensation brightness " and " photometric brightness " (and so on) without any risk of confusion, as the use of the adjective would always be a danger signal.

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* Journal Optical Society of America, Vol. VI., No. 6, p. 527, 1922.

PHOTOMETRIC CONCEPTS. QUANTITY OF LIGHT.

Let it be considered that we deal with monochromatic light or with light in which the relative spectral distribution of energy is always constant. In these cases the "quantity of light" incident on a surface is proportional to the energy incident on the surface in unit time; the photometric "brightness" of a surface is proportional to the amount of light falling on unit area of the retinal image. Thus arise all the usual photometric means of varying the visual brightness of a surface. Some of them may be recalled. Variation of the distance of the source gives a brightness inversely proportional to the square of the distance, provided the light remains normally incident and the dimensions of the source are relatively small. The apparent amount of light transmitted by a very rapidly rotating sector is proportional to the angular opening. The amount of light transmitted by two polarising prisms in series is proportional to the square of the cosine of the angle between their principal sections.

If the discussion is to include the case of light for which the spectral distribution of energy varies, then it is necessary to regard the light as analysed into monochromatic constituents, the luminosity* of each constituent being evaluated as proportional to the energy of some constant and standard

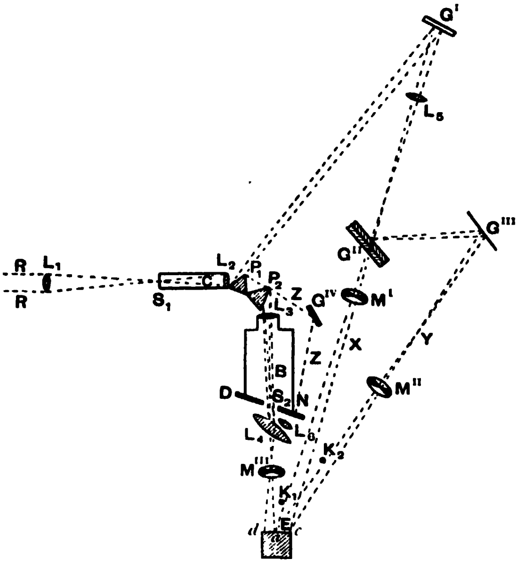

FIG 8.—The colour patch apparatus.
N.B.—For monochromatic analysis the beam from G^1 should be directed towards da.

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* The term "luminosity" is usually employed where *relative* light quantities or brightnesses are discussed.

radiation (white light, say) necessary to produce the same luminous sensation. The total luminosity may be considered to be the sum of the luminosities of the constituents. The basis of heterochromatic photometry is, however, not entirely satisfactory at the present time, in spite of the fact that the work of Abney* and Ives† legitimatises such a summation for certain conditions of observations. The Purkinje effect (a variation of relative luminosity under variations of absolute energy intensity) and other factors enter in to complicate the issue under some conditions, and further study along these lines is required. Sufficient is known, however, to give confidence in the legitimacy of the conception of " quantity of light " for most practical purposes.

MONOCHROMATIC ANALYSIS.

Fig. 8 shows a colour patch apparatus described by Abney, who used a carbon arc as the source of light.

The lens L_4 projects on the white screen *dc* an image of the near surface of the last prism P_2. The slit S_2 formed in the plate D emits monochromatic radiation only, and the image is consequently monochromatic, the hue depending on the position of S_2 in the spectrum. A rotating sector M^{111} can be placed in the beam if it is desired to vary the amount of light in the image. The mirror G^1 can be made to reflect a part of the undispersed beam (white light) also to the same image, and the brightness of this white patch can also be varied by the sector shown in the Fig. at M^1.

It is clear that this apparatus offers a means of varying the colour of the image patch ; the screen may be assumed to possess a perfectly reflecting and diffusing surface‡. (If this is the case its brightness and colour will remain constant for any viewpoint; such points as this are only too easily overlooked, so to save any possible trouble we consider the viewpoint to be fixed.)

" Hue " can now be varied by moving the slit in the spectrum ; brightness can be controlled by varying the two sector apertures equally ; the saturation of the colour can be varied by relative alterations of the amounts of spectral light and white light. By such means it is possible to match any body colour of which the dominant hue lies in the spectrum, *i.e.*, all colours except those between red and violet, such as purple.

In order to *specify* the stimulus necessary to match an unknown colour it is usually given in terms of

(1) wave length of dominant hue ;

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* Abney :—Colour Mixture and Measurement, 1891, p. 86.

† Phil. Mag. 1922, 24, p. 845.

‡ Reflecting in accordance with the cosine law of diffuse reflection.

(2) relative luminosity as compared with white ;

(3) purity of the stimulus ; *i.e.*, the fraction of pure spectral luminosity in the total.

Suppose that a blue card is to be matched. It may be supported at E and illuminated by a second undispersed beam from G^{111} as suggested in the figure. The slit S_2 is closed and the aperture α of the sector M is then varied till the brightness of the patch is equal to that of the blue card illuminated by the steady second beam. The blue card is then replaced by a standard white surface ; the sector has then to be opened to aperture β in order to re-establish the match, then :—relative luminosity of blue as compared with white $= \frac{\alpha}{\beta}$

In order to make the apparatus ready to obtain the other results for various substances some calibration is necessary. By simple experimental devices the ratio of the luminosity of the patch illuminated by spectral light only, to its luminosity when illuminated by the beam from G^1 can be obtained for any position of the slit S_2 in the spectrum From this experiment the " luminosity curve," Fig. 9, for the spectrum can be obtained. With the aid of a suitably calibrated scale it is possible to read off the position of the slit in the spectrum and hence to know the corresponding wave length. The wave length is then found at which the spectral light matches the unknown in hue. A mixture of white and spectral lights is then made which matches the unknown in all respects. The purity of the mixture can be calculated from the relative sector apertures. " Flicker Methods " offer a means of experimental confirmation of the results obtained by ordinary heterochromatic matches, but we shall not be able to discuss these at present.

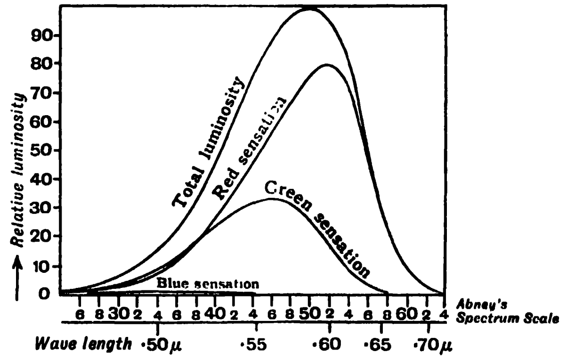

FIG. 9.—Luminosity curves of primary sensations.

Such is the outline of a simple method of monchromatic analysis ; we see how the unknown colour is specified by the dominant hue, purity, and relative luminosity as compared with white, of the artificially produced matching stimulus. If the hue is not a spectral hue a modification of the method is necessary in which the complementary hue can be used.

Ostwald puts the variation in a slightly different form when dealing with colours of reflecting substances or " body colours." If a " pure white " has an amount of 1 of light incident upon it, the amount reflected $= 1$. For a grey which reflects a fraction w and absorbs a fraction s of the incident light we have the equation

$$w + s = 1$$

When a surface exhibiting hue reflects a fraction x of the incident light the portion x may be assumed to consist of a fraction v due to the full colour constituent together with a fraction w due to the white constituent; (the larger w in comparison to v, the less the saturation). The above equation thus becomes

$$v + w + s = 1$$

Naturally if v and w are known, the value of s is also known. Hence for the appearance of a body colour the variables, according to Ostwald, are :—Dominant hue, content of full colour, content of white. The content of black might be specified in place of the white. Ostwald's method of measurement of the " constituents " of the colour is, however, different from the above, and it is to be discussed below.

TRICHROMATIC ANALYSIS.

With the colour patch apparatus described above it is possible to make an instructive experiment by placing three slits of variable width in the red, green and violet regions of the spectrum. The three beams fall on the screen *d a*, Fig. 8, and the mixed radiation is perceived by the eye. Abney arranged an auxiliary apparatus so that a pure spectrum colour could be projected on one part of the screen and the mixture on the other part as suggested in Fig. 10. The experimental fact is that colours of any known hue, and grey, can be produced by varying the proportions of the three spectral constituents in the mixture, but in order to produce a perfect match, more or less white has sometimes to be added to the pure spectral colour on the adjacent screen.

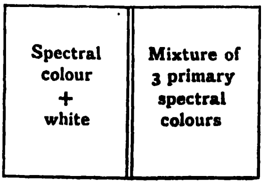

FIG. 10.

Thomas Young* in a famous lecture used the following words :—" It is certain that the perfect sensations of yellow and blue are produced respectively by mixtures of red and green and of green and violet light, and there is reason to suspect that these sensations are always compounded of the separate sensations combined ; at least, this supposition simplifies the theory of colours ; it may, therefore, be adopted with advantage until it be found inconsistent with any of the phenomena ; and we may consider white light as composed of a mixture of red, green and violet only." It is not possible in the present discussion to follow up the history of the famous discussions of colour vision due to later thinkers, amongst whom may be mentioned Helmholtz, Maxwell and, more recently, König and Dieterici, and Abney, as exponents of the theory thus propounded by Young. We are still unsure of the actual mechanism of colour vision, but the theory (and measurements based upon it) can be used with advantage in many problems of colour measurement.

The impossibility of matching some spectral colours at full saturation necessitates the supposition, as Helmholtz pointed out, that the above so-called spectral primaries probably cause a stimulation of all three of the supposed physiologically primary sensations. Abney differed from this view to some extent, but chiefly with regard to the action of spectral red. His experimental analysis of the luminosity curve of the prismatic spectrum yielded the results shown in Fig. 9.

The legitimacy of the summation of the photometric luminosities of heterochromatic stimuli was referred to above. In a similar way Fig. 9 shows that the luminosity of any element of the visible spectrum is to be regarded as the sum of the apparent photometric luminosities due to the simultaneous action of the primary components stimulated to varying degrees by the monochromatic stimulus.

The luminosity of light of wave length λ_1, emerging from a slit in the spectrum plane in the colour patch apparatus may be written

$$L_1=\left(\frac{dE}{d\lambda}\right)_1\left(\frac{d\lambda}{ds}\right)_1 \delta s_1 \; v_1 \quad ,$$

Where $\left(\frac{dE}{d\lambda}\right)_1$ is the relative energy, $\left(\frac{d\lambda}{ds}\right)_1$ is the reciprocal of the dispersion, δs_1 the slit width, and v the relative visibility, all at the wave length λ_1, provided the slit is narrow.

This luminosity is then composed, say, of x% of red sensation luminosity, y% of green, and z% of blue. The actual luminosity of the spectrum of the arc lamp and its composition is shown in Fig. 9 (but not in " percentage " terms). The total luminosity throughout the spectrum due to one sensation is proportional to the area under the corresponding curve, and if it is assumed that " equal stimulation of the three primary sensations shall produce the sensation of white," then, adopting the white of the arc light for our standard, it is necessary to multiply the ordinates of the "green" curve by 2.21 and those of the blue curve by 117 to make the areas under all three curves equal.

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* "Lectures" Kellands Edn. 5, p. 344.

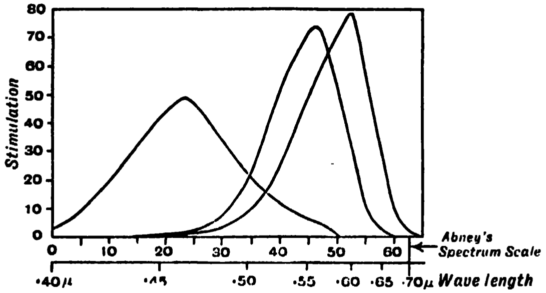

FIG. 11.- Stimulation curves of primary sensations.

Stimulation curves are thus obtained (Fig. 11). Therefore, to calculate the stimulations of the three primary sensations by light from the slit mentioned above, we find them as

$R_1 = \left\{ \left(\frac{dE}{d\lambda}\right)_1 \left(\frac{d\lambda}{ds}\right)_1 \delta s_1 \, v_1 \right\} x$ = Relative stimulation of red sensation.

$G_1 = \{$ Ditto $\}\ y \times 2.21$ = Relative stimulation of green sensation.

$B_1 = \{$ Ditto $\}\ z \times 117$ = Relative stimulation of blue sensation.

The quantity $\left(\frac{dE}{d\lambda}\right)_1 \left(\frac{d\lambda}{ds}\right)_1 v_1$, that is the luminosity for unit slit width, is often determined by direct experiment throughout the spectrum. It gives the luminosity curve.

In such a way it is possible to find the total stimulations from all three (or more) slits. It is useful to form a table showing for each value of wave length the magnitude of the factors vx, 2.21 vy, 117 vz, as well as of x, $2.21y$, and $117z$. The former factors used in turn to multiply the ordinates of an energy distribution curve for any stimulus will yield three curves, the areas under which are proportional to the stimulations of the primary sensations. The latter factors would be used where luminosity rather than energy values are known. In cases where another "white," such as standard sunlight has to be used, the numerical factors 2.21 and 117 will be no longer valid, but the modified values can easily be calculated from a knowledge of the energy distributions and the visibility function, or from relative luminosity.

The whole matter may now be dealt with in a very interesting manner used both by Maxwell and Helmholtz and originating apparently out of a suggestion of Young, namely, the colour triangle. It is interesting to note that the use of graphical methods originated with Newton, who proposed the use of a colour circle and described a graphical means of determining the results of colour mixtures. Had his experimental apparatus been of a more perfect description he would undoubtedly have gone very far in developing the theory of this subject.

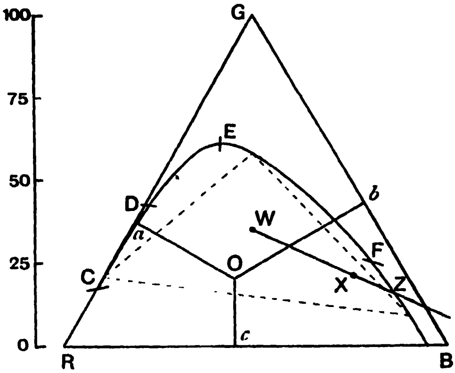

FIG. 12.—Colour triangle (red, green and blue sensations) showing approximate portions of frauntrofer lines in spectrum curve.

The colour triangle is shown in Fig. 12. It is equilateral and the height is 100. Taking any point O and dropping perpendiculars to each side, we know that the sum of the lengths of the three is equal to 100. Let us suppose that the stimulation causing a certain colour sensation is composed (on the above principles) of 50% red stimulation, 20% green and 30% blue. It is an easy construction to find the point O in the figure where $Ob=50$, $Oc=20$, and $Oa = 30$. In this manner we can represent "percentage amount of red stimulation" by the perpendicular distance of a point from the line. The point R represents 100% of red stimulation and 0 % of green and blue, and so on.

To look at the matter in a different way, we might place a mass 50 at the point R, 20 at G, and 30 at B. Then the point O is the centre of gravity of these three masses.

The experimental results for percentage composition of luminosities throughout the spectrum enables us to calculate the stimulation values for the spectrum colours, and hence to plot them in the triangle as is shown in the figure. The curve is concave to white, which lies obviously at the centre of the triangle. On the spectrum curve we may select the three points corresponding to the three slits of the fundamental experiment and join them by a new triangle. It will be clear that only the colours lying within this interior triangle can be realised by a mixture of the original physical primaries, and it is clear why some of the spectral colours cannot be matched at full saturation.

We are now ready to make the fundamental test of the validity of this trichromatic analysis.

With the aid of the colour patch apparatus with the three slits in the spectrum a mixture is made to match some unknown colour, say the blue already dealt with by monochromatic analysis. The fundamental stimulation of the primary sensations can then be calculated for the matching stimulus in the manner indicated above.

Let the values thus found be R_b, G_b, and B_b. The corresponding point (X) in the triangle is the centre of gravity of proportionate masses placed at the respective corners R, G, and B. This is most easily found by multiplying each of R_b, G_b and B_b by the factor $\frac{100}{R_b+G_b+B_b}$, when we obtain the perpendicular distances of the required point from the three base lines. The corresponding spectral hue is given by drawing a line WX through the centre point of the triangle (white) and the point just found. This line intersects the spectrum curve in a point corresponding to the dominant hue, which should agree with that found by monochromatic analysis. In order to complete the correspondence it remains to reduce the matching stimulus found by the monochromatic analysis into terms of stimulations and the final correspondence of the two independent measurements should emerge.

These fundamental "stimulations" are evidently the ultimate basis of reference in all cases of colour measurement.

The most noteworthy extant data for the colour stimulations are due to König and Dietrici* and to Abney†. Their results are compared by E. A. Weaver‡, who has evolved a set of data based on the results of both researches. Since the primaries of Abney were quite different from those of König and Dietrici, the comparison was difficult, and it is highly to be desired that independent determinations should be undertaken with the improved apparatus and fuller knowledge of the retinal responses to light which recent years have provided. More especially it is desirable to know how far these results are valid for the vision of different persons of apparently normal colour perception since, according to Weaver, there are indications of considerable differences in the "luminosity curves" for different "normal" observers under similar conditions, although corresponding differences are not found to appear in the primary stimulation curves. Such investigations are fundamental to further progress in colorimetric research.

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* Zeit. f. Psychol. und Physiol. d. Sinnesorg, 4, 241, 1892.

† Researches in Colour Vision.

‡ Journal Opt. Soc. America, 6, p. 527, 1922.

Progress along these lines is being made by Ives and Priest.* Ives has given two useful papers† on the transformation of colour mixture equations, giving details of graphical methods such as were briefly suggested above. He employs the colour mixture curves of König and Dietrici, slightly modified by reasons depending on the consideration of the luminous values of the sensations. His standard "white" is that corresponding to a black body at 5,000°. Fig. 13 shows the fundamental sensation triangle giving the position

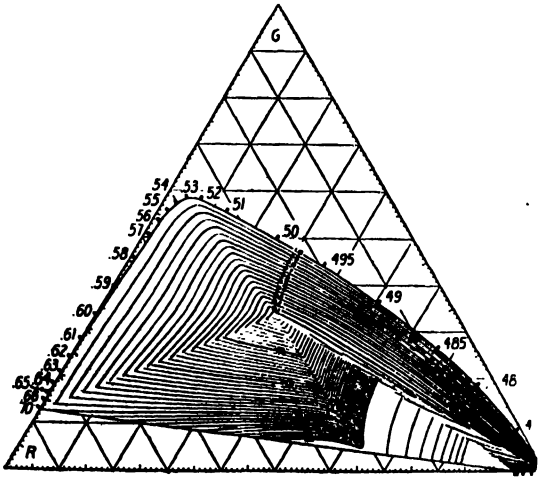

FIG. 13.

of the spectrum with the wave lengths duly marked out; the inner curves show the fractional amounts (v) of the spectral colours in terms of luminosity to be mixed with white (w) to form colours of all spectral hues and saturations where

$$v + w = 1.$$

From this figure it is thus possible to read off the purity of a stimulus corresponding to any point within the spectrum curve. These curves aid the reduction of trichromatic measurements to terms of monochromatic analysis.

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* Priest has developed apparatus for monochromatic analysis. Jour. Opt. Soc. Amer., Vol. 8, p. 173, 1924.

† Jour. of Franklin Inst., Dec., 1915, p. 673. Jour. of Franklin Inst. Jan., 1923, p. 23.

For a complete description of the method of obtaining them the original paper should be consulted. Ives has also had considerable success in co-ordinating colour measurements made on different systems.

Simultaneous measurements by Trichromatic and Monochromatic Analysis H. E. Ives (from the Journal of Opt. Soc. of America, April, 1923).

	Trichromatic Analysis.		Monochromatic Analysis.	
Lamps.	λ	% Purity.	λ	% Purity.
Hefner Lamp ...	.589 μ	87	.591 μ	86
Welsbach Mantle ...	.584 ,,	79	.5824 ,,	71
Quartz Mercury Arc	.494 ,,	17	.5068 ,,	15
Filters				
Yellow Primary ...	.5901 ,,	99	.5931 ,,	100
Green Primary ...	.4985 ,,	61	.5078 ,,	63-2
Blue Primary ...	.4780 ,,	12	.4856 ,,	25

It is quite clear that these results afford much ground for hope that the fundamental theoretical basis of the transformation method is sound enough for all practical purposes.

The foregoing description has afforded a very hasty survey of the foundations on which the theory of colour measurement is being constructed. It cannot be claimed that the structure is nearly perfected. We must now pass to a review of the work that has been accomplished in the standardisation of colours and in the development of practical instruments for colour measurements.

STANDARDISATION OF COLOURS.

It is easily possible to prepare a series of grey surfaces which have photometric reflection co-efficients 0.1, 0.2 . . . 0.8, 0.9 and 1.0, taking a fairly pure white surface, such as that of a magnesium carbonate block, for the reference of reflecting power 1. It is then seen that the steps of apparent brightness are by no means equal. The higher members seem to show too little contrast, while the lower members exhibit too much. This is in accordance with Fechner's law which, as applied to the present case, may be expressed

$$dS = K\frac{dI}{I}$$

where dS is the change in psychological sensation caused by a changed I in the original energy I ot the stimulus. The production of a grey series of *apparent* equal steps, therefore, calls for a series in which the reflection coefficients follow a geometric law. The logarithms of the reflection coefficients now follow an arithmetic progression.

By the integration of steps of "just perceptible colour change" in the spectrum, or from certain other considerations, it is possible to establish a scale of spectral colour measurement in which equal steps correspond to equal changes of colour. From the point of view of appearance the scale is more significant than one of wave length.

Should we make a series in which a variation between a full colour and black takes place ($v + s = 1$ in Ostwald's notation) the content v of full colour must follow a geometric law in terms of luminosity in order to secure steps of apparent equality; a similar proviso applies approximately to the amount of white in a series ranging from full colour to white.

Colour Charts.

Considerations such as these form the basis on which colour charts are built up. The ideas are followed out in Ostwald's Farbenatlas*, in which spectral colours and purples at equal distances on the psychological colour scale are graded with various contents of black and white.

The full atlas gives 2,500 indexed colours, while a smaller atlas (Der Farbkorper) gives 768 of the main steps in the larger series. The physical examination of Ostwald's colours has been begun by Kohlrausch.

A somewhat similar atlas due to Munsell has been published in America. In this atlas the colours are graded through different saturations (Munsell's term is *chroma*) and brightness (Munsell's term is *value*). The examination of the colours has been begun by the Washington Bureau of Standards. In this latter case the grading of the colours does not depend on the same system as that used in Ostwald's atlas.

Such charts offer a definite, though more or less arbitrary, scheme of colour standardisation. The question of permanence, accuracy of reproduction, ease of comparing an unknown colour with one in the atlas, and, lastly, the expense of production, are all factors of importance. Before leaving the subject the charts due to Ridgway and the Société des Chrysanthemistes should be mentioned.

I have recently been greatly interested to hear that an American firm of drapers, the Wm. Filene's Sons Company, of Boston, Mass., has brought out a small colour chart, the Colourscope, and are using it in connexion with their business for developing interest in colour questions. With its aid customers can study questions of colour harmony in dress and home decoration. There seem to be possibilities in connexion with the development of mail order business. The chart is founded on the Munsell system, and by the kindness of the above company I am exhibiting one this evening.

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* **Ostwald's books are published by J. A. Barth, of Leipzig.**

Lovibond's Standards.

Without providing a complete set of standards ranging with small intervals over the whole gamut of body colour, it is possible to take advantage of the facts of subtractive colour mixture in order to dispense with colour scales in all but three hues; namely, those which comprise the so-called subtractive primaries—crimson, yellow green and blue. The standards consist for each hue of a set of " flashed glass " filters in which the densities* for any wave length follow an approximately arithmetic progression. Each filter is numbered in terms of the relative density as compared with the unit, so that, for example, filter 30 is the equal of two filters 15 placed in series. Filters of equal scale number in the three hues combine always to give a grey. With a complete set of filters of this kind, it is possible *directly* to standardise almost any colour, except (as in the case of additive colour mixture) a limited range of the more saturated colours of hues intermediate between those of the primaries. The required conditions for psychological equality of steps is fulfilled, and if the laws connecting density, wave length and scale numbers are known for the three hues the " Tintometer " indications can be reduced to terms of primary stimulations. Some information as to the law of density variation in actual filters is given in the Journal of the Oil and Colour Chemists' Association, No. 27, Vol. IV., November, 1921. In a case of this kind accuracy of reproduction is the factor of first importance. The whole system is a remarkable achievement of a very original mind, and when it is said that the late Mr. Lovibond approached the subject as a science in itself and not at all from the standpoint of orthodox physical science, the merit of his work can better be realised. In passing it may be noted that the accurate working of the system requires diffused daylight, such as from white clouds. The three filters of equal scale number give a subjective grey, but the actual spectral transmission rises greatly towards the extreme red. Consequently care must be exercised if it is desired to use the system with any of the usual forms of artificial daylight lamp. If this is done the results obtained will probably not repeat in actual daylight. The makers of the Tintometer have developed a special lamp of their own, which is said to be satisfactory under certain conditions.

Ostwald's Standards for Colour Measurement.

Ostwald has developed a system† of colour measurement which depends on the use of a limited number of standard colour objects, but on an entirely different principle from that of the Tintometer. A psychological colour circle is derived in which near colours mix to give the colour midway between them. Complementary hues are at opposite ends of a diameter, and Hering's psychological primary yellow, red, ultramarine and sea green are separated from each other by 90°. The spacing is checked by integration of colour difference threshold measurements. The corresponding body colours are all realised on a series of five cardboard strips. A simple apparatus, Fig. 14,

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* $\text{Density} = \log \dfrac{\text{incident energy}}{\text{transmitted energy}}$

† Die grundlage der messenden Farbenlehre. W. Ostwald. Barth. Leipzig, 1921.

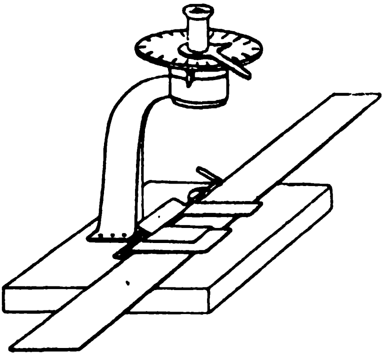

FIG. 14.

containing a nicol and a double image prism permits images of a test colour and a section of one of the cards to be superposed in any required proportionate intensity. By comparison with a grey, the condition that the test and the standard are complementary colours can thus be realised; the dominant hue in the test colour can then be found from a table of complementary hues.

To explain the method of obtaining the black and white contents of a test colour would require a full exposition of Ostwald's theory of the "colour half," for which we have not time. Roughly expressed, the principle assumes that the majority of body colour stimuli include stimuli by no means from a limited portion, but from a half of the colour circle. Assuming the equation given above $v + w + s = 1$ for body colours, imagine that the test surface is illuminated by light of the same colour as its own, and this light also illuminates a graduated strip of neutral grey shaded from white to black. If the black content of the grey strip at the point of equality is s, then the black content s of the test colour must be equal to s. The test colour and grey strip can then be illuminated by light of the complementary colour. The white content of the test colour is then equal to the white content of the strip at the matching point. Instead of using coloured light for illumination appropriate colour filters may be used for viewing the match; this obviously produces the same effect. The viewing apparatus is shown in Fig. 15. In practice seven colour filters are found sufficient for use with the whole range of colour measurements required; each of these acts as a "transmitting filter" for one spectral range and as an "absorbing filter" for the opposite range in the colour circle. Since in the equation $v + w + s = 1$, w and s are thus measured, the value of v follows.

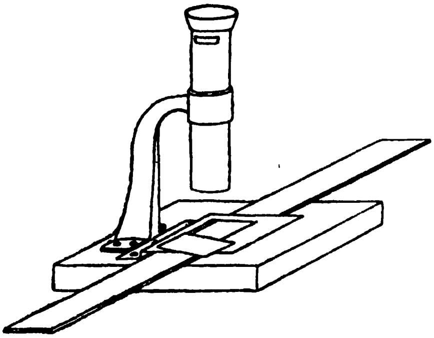

FIG. 15.

DEFINITE PROBLEMS IN COLOUR MEASUREMENT.

After the foregoing review of colour theory and standardisation it will be well now to notice very briefly some of the industrial and scientific operations in which colour measurement is being developed as a convenient method of control. In the printing, colour, and dye industries, and in the drapery trades, the applications of colour measurement are manifold. Any system used must be applicable over the whole range of colour. One of the most interesting modern questions is the investigation of the fading of colours and dyes under various conditions. The mercury arc in quartz, suitably screened with filters of thin glass, is successfully used to imitate sunlight, and methods are being rapidly developed. There is in this connexion a useful field for improved method of detecting and measuring the amount of fading, and this clearly should be done directly by colour measurement. The Tintometer has been successfully applied in this connexion.

Colour measurements are of great importance in the manufacture of many foods and beverages, including butter, margarine, oils, preserves, beers, wines and the like. Chemical determinations, of considerable difficulty by orthodox methods, can often be greatly simplified by the use of colour tests.

Colour measurements are useful in a considerable number of industrial processes, but there is often no necessity to use systems applicable over the whole range of colour. To take a simple example, sugar manufacturers, tanners and others may wish to compare samples of brown liquid for depth of colouration. There is no necessity to adopt expensive systems or instruments covering colours which are never encountered. Messrs. Tintometer, Ltd., have done useful work in developing series of standards useful in various trades. In an increasing number of pathological methods colour measurements are finding an increasing employment, and here, again, measurements over limited ranges are usually called for.

One interesting application of colour measurement is the determination of X-ray exposure by the colour change occurring in the Sabouraud-Noire or Levy pastille under the action of the radiation. The Tintometer has been successfully applied to this purpose by Dr. Dudley Corbett. Several systems have been developed for the measurement of colours of low saturation; such measurements are of importance in connexion with the manufacture of flour, cement, paper, sugar, and other "white" products, and also in laundry work. Sufficient has now been said to indicate the general nature of the applications of colour measurement in industry. The next lecture will deal with some more of the instruments actually in use.

DR. MANN JUVENILE LECTURE.

The second and concluding Juvenile Lecture for the present Session was delivered by LIEUT.-COLONEL E. H. RICHARDSON on Wednesday afternoon, January 14th, the subject being "Dogs in Peace." LORD ASKWITH, K.C.B., K.C., D.C.L., late Chairman of the Council of the Society, presided.

Colonel Richardson said that while the training of dogs for military purposes was entirely a matter for experts, there were many ways in which laymen could utilise the wonderful intelligence of their dogs for peaceful purposes. The fact that the dog possessed very acute powers of scenting and hearing made it of great use for all detective purposes; while its intense desire to serve and its delight in any work within its capacity, was a splendid basis on which to start training. The devotion of the dog to its master was one of the wonders of creation; there was nothing in the animal kingdom to compare with it, for in no equal degree did we receive from any other animal the whole-hearted unselfish comradeship which the dog gave to us. This comradeship was of very ancient origin. The cave men kept dogs, and the Greeks and Romans used large numbers of dogs to police their forts. A slide was exhibited showing a curious suit of armour (now in the possession of the Spanish Museum at Madrid), worn by the dogs which accompanied the Crusaders. Another illustration showed Sir Edwin Landseer's well-known painting "Save," which was founded upon fact. Recently, 92 passengers and the crew of a coasting steamer wrecked off Newfoundland were saved through the intelligence of a Newfoundland dog belonging to one of the men. It was too rough to put off a boat, but a light line was tied around the dog, who obeyed his master's signs and swam ashore with it. This made it possible to rig up a tackle by means of which all were brought ashore. The monks of St. Bernard recognised the succouring instinct in dogs when trained to seek out lost travellers in the snowy passes of the Alps. In his own training work he continually appealed to this instinct, as once the desire to save was cultivated, it was always ready for use in many unexpected directions. He instanced a case where the wife and child of the Rev. Roffe Sylvester had been saved through the instrumentality of their Airedale dog, "Rustler." Both would have lost their lives through an escape of gas had not the dog aroused Mrs. Sylvester by scratching vehemently at her arm. This dog was exhibited at the lecture.

All good training must be based on affection and co-operation between master and dog. Of course, discipline must be inculcated, but great patience was necessary, and there must be no whipping or rough treatment. Reward for good work done and the sound of the voice were the best educators. He thought nothing could be more interesting than to watch the intelligence of a collie tending a flock of sheep. Only last week they had had an instance of the sagacity and sense of duty conceived by one of these dogs. The shepherd had been missing for two days on the hills and was eventually found dead. But all the time the collie had carried on the tending of the flock entirely by itself. The natural guarding instinct so deeply implanted in the dog led into many channels of interest which could be adapted to the needs of man as a guard and companion. A few years ago dogs were employed for the protection of Cabinet Ministers in this country. One picture showed a dog guarding a famous shrine at an Abbey in the South of England. Pictures of the bull-mastiff "Britain" employed to guard important positions on the rock of Gibraltar, and of other guard dogs who had served with our naval forces were also shown. Many of the dogs at work with the police and elsewhere at the outbreak of war, were mobilised and sent out to the trenches as sentry dogs.

In connexion with the work of police dogs, Colonel Richardson mentioned that he had made a long study of this particular branch of dog training and for years past had trained dogs for patrolling suburban districts in company with constables on night duty. The dog must be well disciplined and not liable to bite harmless pedestrians—his duty being merely to give warning, by growling or barking, of any one hiding by the roadside, and to search them out in obscure places invisible to the policeman. At the same time a good dog would, in the event of the policeman being attacked, go to his rescue at once. This needed plenty of courage, and the dogs had to be taught various forms of exercise to test their courage and reliability. They were trained to face revolver fire, and to attack at the word of command, so that they would know exactly what to do if the policeman required their aid. Foreign police forces used dogs a great deal. But the conditions were somewhat different on the Continent. and the dogs were as a rule more savage in disposition.

It was often said that dogs had no nationality. This, however, was a mistake, for dogs absorbed from their master the same mentality and expressed it. Our own native breeds suited this country best, and he deprecated the number of Alsatian dogs which were being imported into the kingdom. Great claims were made for this class of dog, but he could state most emphatically that for intelligence, good temper, courage, reliability, and devotion to duty, there were no dogs in the world which could excel those of Great Britain, and there was no need to go to foreigners to help us to guard and protect our own people when we had so many magnificent breeds of our own.

Most of the pictures which had been shown were those of Airedale dogs. He had made a speciality of Airedales because they excelled by temperament and tradition for this particular class of work. There were, however, many other British breeds which were excellent and could be trained to be good police dogs. Dogs which could track were extremely useful, and bloodhounds from time immemorial had been used for this purpose. Before the police force was established, villagers were ordered to keep tracking dogs, and a tax was made for the maintenance of such dogs, which were regarded as an absolute necessity in certain parts of the country during the Middle Ages. Pictures of a fine brace of bloodhounds which were trained to a high pitch of perfection and did some very interesting work with the police, were shown; as well as views of dogs used for guarding and police purposes in India and the Malay States, and for tracking escaped prisoners from an American penitentiary. In this country, except under exceptional conditions, tracking work was very difficult nowadays, as tarred roads and the immense amount of traffic prevented the scent from lying. Still there were occasions where trackers could be usefully employed in country districts, provided they could be on the ground early enough.

Colonel Richardson thought it might be interesting if he stated clearly how far the possibilities of bloodhound tracking could go and what the limitations were. Neither a bloodhound nor any other kind of dog could track through crowded streets. A trail might be followed early in the morning before many were about and shortly after the person who was wanted had passed along, but it must be understood that scent hardly lay at all on hard surfaces like pavements or tarred roads. It was essential, too, to have some clear idea as to where the fugitive started from. It was no use showing a hound a boot or article of clothing with the idea that the animal would carry the person's scent in its mind, and search over a very wide area. It was necessary to give some definite idea that a person had passed along a certain road or lane, or across a meadow, within recent time. It was then quite possible to set the animal at work, provided the atmosphere and the surface of the ground were favourable.

A very fine bloodhound ("Marwood Minster"). which was undergoing instruction in tracking work, and had taken part in bloodhound trials, was shown by the owner, Mrs. Edmunds; and also a dog which had been trained to carry parcels.

On the motion of the Chairman (Lord Askwith), a cordial vote of thanks was unanimously passed to Colonel Richardson for his interesting course.

BEQUEST TO THE SOCIETY.

THOMAS GRAY MEMORIAL TRUST.

The late Mr. Thomas L. Gray, who was elected a Life Member of the Society in 1892, and died about a year ago, appointed the Society his residuary legatee for the purpose of founding a memorial to his father, Thomas Gray, C.B. The terms of the bequest are as follows :—

EXTRACT FROM THE WILL OF THE LATE THOMAS LOWE GRAY.

I direct my Trustees to stand possessed of my residuary estate Upon Trust to pay or transfer the same to the Royal Society of Arts of John Street Adelphi in the County of Middlesex the income thereof to be applied by them for the purpose of providing a Memorial to my late father Thomas Gray who was for many years Assistant Secretary to the Board of Trade (Marine Department) and the author of the "Rules in Rhyme." And I declare that the bequest shall be known as "The Thomas Gray Memorial Trust" and shall have for its objects the advancement of the science of navigation and the scientific and educational interests of the British Mercantile Marine those being the objects to which my late father devoted his life and by way of explanation of the objects for which the said Thomas Gray Memorial Trust is to be held I declare that the first of such objects namely the advancement of the science of navigation could in my opinion be usefully promoted by the offer of prizes for new inventions relating to the science of navigation the giving of awards to any person who shall have introduced improvements of any importance the making of grants in aid of scientific research connected with the subject and the institution of lectures on the science of navigation and kindred subjects And that the second of such subjects namely the scientific and educational interests of the British Mercantile Marine could be usefully promoted by the offer of prizes scholarships or grants to provide educational facilities either to students or teachers or by the offer of prizes for essays on and awards for the saving of life at sea.

It is expected that the amount available for the Trust will be about £7,000. The Council are preparing a scheme for the purpose of carrying out the terms of the bequest, and as soon as this is completed particulars will be published in the *Journal*.

Thomas Gray was born in 1832, and he entered the Board of Trade as a boy clerk in 1851. He was a very vigorous and forceful man, and he became the Head of the Marine Department at the age of 37. He was in charge of this Department during the whole of the seventies and eighties of last century, a period when our shipping was developing very fast, and when the system of regulation and control was gradually assuming its present form. In all this work Thomas Gray took a prominent part, and he was deeply interested in everything relating to ships and navigation. The rules of the road at sea were to a large extent formulated under his superintendence, and the "Rules in Rhyme," a sort of *memoria technica* for them, are familiar to seamen. The following passages are still quoted in the "Regulations relating to the Examination of Masters and Mates in the Mercantile Marine," issued by the Board of Trade :—

1. *Two Steam Ships meeting.*

When both side lights you see ahead—
Port your helm and show your **Red.**

2. *Two Steam Ships passing.*

GREEN to GREEN—or, RED to RED—
Perfect Safety—Go ahead!

3. *Two Steam Ships crossing.*

Note.—This is the position of greatest danger: there is nothing for it but good look-out, caution and judgment.

If to your starboard RED appear,
It is your duty to keep clear;
To act as judgment says is proper:—
To Port—or Starboard—Back—or, Stop her.
But when upon your Port is seen
A Steamer's Starboard Light of GREEN,
There's not so much for you to do,
For GREEN to Port keeps clear of you.

4. *All Ships must keep a good look-out, and Steam Ships must stop and go astern, if necessary.*

Both in safety and in doubt
Always keep a good look-out;
In danger, with no room to turn,
Ease her, stop her, go astern.

Thomas Gray was a Member of the Society from 1885 until his death in 1890. For many years before his election, he had rendered useful service to the Society. In 1866 he read a paper on "Modern Legislation in regard to steamships," and he frequently attended the meetings and took part in the discussions.

OBITUARY.

SIR THOMAS JEWELL BENNETT, C.I.E.—Sir T. J. Bennett died suddenly at his London residence, 38, Hans Place, on January 16th, in his seventy-third year. He was a staunch and zealous supporter of the Society for close upon a quarter of a century. Elected a Fellow in 1901, he had ever since been an active member of the Indian Section Committee, and from 1907, with short intervals, owing to absence abroad, he was a member of Council. In 1902 he read a paper on "The Past and Present Connection of England with the Persian Gulf," and frequently spoke at meetings of the Society, particularly those relating to the East. His last appearance here was in June, when he proposed a vote of thanks to Lord Askwith on relinquishing the Chairmanship of the Council.

Born at Wisbech, he was a son of the late Mr. T. J. Bennett and a kinsman of the musical composer, Sir William Sterndale Bennett. A journalist by profession, he was as a young man on the staff of an old and well-known Western journal, the *Bath Chronicle*, his next post being in the neighbouring city of Bristol, where he was Assistant Editor of the *Western Daily Press*. He afterwards came to London to be a leader writer on the *Standard*. In 1884 he went to India, where he soon made his mark as a capable and perspicacious guide of public opinion. He was in the first instance associated with the late Mr. Grattan Geary in the editorship of the *Bombay Gazette*, retaining that position until 1892, when upon the death of Henry Curwen, Bennett became editor and chief proprietor of the *Times* *of India*, once described by Lord Curzon of Kedleston as "the leading paper in Asia." Bennett considered personal participation in the affairs of public bodies incompatible with the performance of editorial duties in India, but he took part as a Fellow in the management of local University affairs, and in all other ways was useful in important movements. Upon his retirement from the active editorial control of his paper some 3,000 Gujerati agriculturists, whose grievances he had brought to the notice of Government, presented him with an address.

An effective speaker, he was a hardworking member of the House of Commons, and always secured the attention of the assembly when he dealt with Indian questions. His first attempt to enter Parliament, in 1910, as Conservative candidate for the Brigg division of Lincolnshire, proved unsuccessful, but in 1918 he was returned in the same interest for the Sevenoaks division of Kent, and continued to represent that constituency until the General Election of 1923, when he failed to keep the seat.

NOTES ON BOOKS.

THE SEASONING AND PRESERVATION OF TIMBER. By Ernest G. Blake. London: Chapman & Hall, Ltd. 9*s*. 6*d*. net.

In view of the enormous consumption of wood at the present day, and the prospect of a world shortage of timber with which those interested in forestry threaten us, the necessity for preparing and preserving our supplies in the best possible way is obvious. This handbook gives an excellent account of these various methods.

The earlier attempts at artificial seasoning met with poor results, and this naturally led to prejudice being formed against the idea. In recent years, however, a great deal of scientific work has been done in this connexion; immense care has been expended in ascertaining exactly what happens at the various stages of seasoning, and with the substitution of a moist and steaming atmosphere for a dry heat it is now claimed that timber suffers no injury from the process.

As the various factors of climate, rainfall, temperature, attacks of insects, etc., vary infinitely in different countries, it is clear that no system of preservation can be prescribed as the best in all circumstances. Mr. Blake describes all the best known antiseptic and impregnating processes, and his book should therefore be of use to builders, architects, engineers and all users of timber in different parts of the world.

MODERN MASTERS OF ETCHING. By James McBey. With an Introduction by Malcolm C. Salaman. London: The Studio, Ltd. 5*s*. net.

The first book of this series, dealing with the work of Frank Brangwyn, was reviewed in the *Journal* of December 19th last. The welcome given to that volume is now extended with equal warmth to its successor. A brief but interesting and competent account of McBey and his etchings by Mr. Malcolm Salaman is followed by twelve reproductions of the artist's best known works. There is a quality about these etchings—especially those dealing with ships and water—which possesses an extraordinary charm, and the reproduction of them here, for softness, delicacy and depth of tone, leaves nothing to be desired. In particular, we would select for mention the plates of "The Pool," which gives an admirable idea of the busy Port of London, "The Torpedoed Sussex," "Ebb Tide" and "Zaanstreek," where the reflections of the boats are rendered with the most charming effect.

We hope that this series will receive the appreciation which is its due, in order that the publishers may be encouraged to make it as long as possible.

GENERAL NOTES.

THE MERCHANTS' ASSOCIATION OF NEW YORK.—This Association, which is comprised of the leading corporations and firms in New York, has for one of its objects the placing of foreign houses wishing to buy or sell merchandise, or to make agency arrangements in the United States, in direct touch with prominent American firms. For this purpose a complete and carefully organised card index is maintained showing the overseas business interests of thousands of American houses. The Association offers to assist any Fellows of the Society anxious to make use of its services, without any cost whatsoever, and invites them to communicate with the Secretary, Merchants' Association of New York, Woolworth Buildings, New York City.

ARTIFICIAL SILK.—A conference of Hangchow and Shanghai dealers was recently held in Shanghai "to protest against the use by some Chinese manufacturers of fibre silk or floss." According to the Chinese Economic Bulletin it was resolved to inform the public by announcement in newspapers of tests for artificial silk, to appeal to the provincial authorities to stop the sale of artificial silk under the name of real silk, and to ask the silk merchants' guilds in Hangchow and Shaohing to co-operate in discouraging its sale.

NEW AERIAL CAMERA INVENTED IN AUSTRALIA.—According to a report by the United States Assistant Trade Commissioner at Melbourne, a new aerial camera, the invention of Mr. W. H. Hansom, of Victoria, has recently been completed at the engineering works of the Shaw-Ross Aviation Co. at Port Melbourne. The inventor claims that he has taken oblique photographs when flying at 126 miles an hour. The camera is very rapidly operated and on one occasion took 12 photographs in three minutes when flying. The most original feature is the focussing—for the focus can be instantly changed in the air between the limits of 25ft. and 10,000 ft.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, JANUARY 26..Geographical Society, 135, New Bond Street, W. 8.30 p.m. Brig.-Gen. the Hon. C. G. Bruce and Major Northey, "Nepal."

Public Health, Royal Institute of, 37, Russell Square, W.C. 4.30 p.m. Prof. E. L. Collis, "Phthisis and Industrialism (National and Occupational) with reference to other Infectious Diseases." (Lecture I.)

Architectural Association, 34, Bedford Square, W.C. 8 p.m. Miss Margaret Jourdain, "The Architect as Designer of Furniture."

Victoria League, 22, Eccleston Square, S.W. 5 p.m. Sir Francis Younghusband, "India."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 7 p.m. (Informal Meeting.) Mr. S. W. Melsom, "The National Physical Laboratory and its Work."

(North Eastern Centre.) Armstrong College, Newcastle-on-Tyne. 7.15 p.m. Mr. L. H. A. Carr, "The Use of Induction Regulators in Feeder Circuits."

London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. Dr. E. B. Behrens, "Constitution of International Labour Organistaion."

University of London, University College, Gower Street, W.C. 5 p.m. Prof. G. E. Smith, "The Anatomy and Physiology of the Sympathetic Innervation of the Striated Muscle." (Lecture II.)

4.15 p.m. Prof. L. M. Brandin, "Berthe au grand pied." (In French.)

At King's College, Strand, W.C. 5 p.m. Dr. J. A. Hewett, "Carbohydrate Metabolism." (Lecture II.)

5.30 p.m. Rev. C. F. Rogers, "Ecclesiastical Music." (Lecture I.)

5.30 p.m. Mr. C. J. Gadd, "Some Results of the Excavations at Ur."

Actuaries, Institute of, Staple Inn Hall, Holborn, W.C. 5 p.m. Mr. C. R. V. Coutts, "Notes on Life Assurance Investment Policy."

TUESDAY, JANUARY 27..Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 8 p.m. Mr. J. W. T. Walsh, "The Effect of Internal Obstructions on the Performance of a Lighting System."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C. 4 p.m. Mr. R. A. White, "Ireland as a Food Supplier to Great Britain."

Royal Institution, Albemarle Street, W. 5.15 p.m. Dr. H. R. Hall, "The Connections and Relations of the Prehistoric Greek and Ancient Egyptian Civilisations." (Lecture I.)

Anthropological Institute, 50, Great Russell Street, W.C. 8.15 p.m. (Anniversary Meeting.)

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. (1) Dr. E. H. Salmon, "The Southampton Floating Dock." (2) Mr. F. E. Wentworth-Sheilds, "Southampton Floating Dock: Subsidiary Works."

Electrical Engineers, Institution of (North Midland Centre), The University, Leeds. 7 p.m. (Faraday Lecture.) Prof. G. W. O. Howe, "World-wide Radio Telegraphy."

Public Health, Royal Institute of, 37, Russell Square, W.C. 4.30 p.m. Prof. E. L. Collis, "Phthisis and Industrialism (National and Occupational), with reference to other Infectious Diseases." (Lecture II.)

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. G. E. Smith, "The Evolution of Man."

At King's College, Strand, W.C. 5.30 p.m. Rev. W. R. Matthews, "The Philosophy of Religion."

At the School of Slavonic Studies, Malet Street, W.C. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia from 1861." (Lecture II.)

Roman Studies, Society for the Promotion of, at the Society of Antiquaries, Burlington House, Piccadilly, W. 1. 4.30 p.m. Prof. S. Jones, "The Apostles in Rome and the Relations of Christianity with the Imperial Government."

WEDNESDAY, JANUARY 28..British Academy, at the Royal Society, Burlington House, Piccadilly, W. 5 p.m. Sir John Morris-Jones, "Sir John Rhys."

Design and Industries Association, at the London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. "The Principles of Design applied to Textiles."

Microscopical Society, 20, Hanover Square, W. 7.30 p.m. (Industrial Applications of the Microscope Section.) The Use of the Microscope in the Dairying Industry. (1) Prof. R. S. Williams, Introductory Address. (2) Mr. N. Wright, "The Structure of the Udder, Normal and Abnormal." (3) Mr. A. T. R. Mattick, "The Differentiation of the various Cells found in Milk." (4) Mr. L. J. Meanwell, "The Application of the Microscope to the Detection of Tuberculous Infection." (5) Mr. John Golding, "Fat Globules." (6) Miss E. R. Hiscox, "The Separation and Identification of Micro-Organisms causing Faults in Milk Products."

Electrical Engineers, Institution of (South Midland Centre), at the Midland Institute, Birmingham. 7 p.m. Prof. G. W. O. Howe (Faraday Lecture), "World-Wide Radio Telegraphy."

Public Health, Royal Institute of, 37, Russell Square, W.C. 4.30 p.m. Prof. E. L. Collis, "Phthisis and Industrialism (National and Occupational), with reference to other Infectious Diseases." (Lecture III.)

University of London, University College, Gower Street, W.C. 5.30 p.m. Mr. J. H. Helweg, "English Influence on Danish Literature in the XIXth Century." (Lecture II.)

6 p.m. Mr. H. Higgs, "Financial Problems of Europe." (Lecture II.—"France.")

At King's College, Strand, W.C. 5.30 p.m. Rev. C. Jenkins, "The Age of Christian Pilgrimages, A.D. 500-800."

At St. Bartholomew's Hospital Medical College, 6, Giltspur Street, E.C. 5 p.m. Prof. C. L. Evans "The Physiology of Plain Muscle." (Lecture III.)

Literature, Royal Society of, 2, Bloomsbury Square W.C. 5 p.m. Mr. John Buchan, "The Old and the New in Literature."

THURSDAY, JANUARY 29..Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p.m.

Victoria and Albert Museum, South Kensington, S.W. 6 p.m. Mr. A. J. Koop, "Chinese Bronzes."

Royal Institution, Albemarle Street, W. 5.15 p.m. Sir William Bragg, "The Properties and Structure of Quartz." (Lecture I.)

University of London, University College, Gower Street, W.C. 5 p.m. Dr. A. S. Parkes, "The Physiology of Reproduction." (Lecture II.)

5.15 p.m. Prof. J. E. G. Montmorency, "African Customary Law, with special reference to Early Egyptian Law." (Lecture II.)

At King's College, Strand, W.C. 5 p.m. Dr. A. W. Pollard, "The Supply of Books to English Readers from the time of Caxton to the Outbreak of the Civil War, 1475-1642." (Lecture III.)

6.30 p.m. Dr. O. Vocadlo, "Czech Civilisation." (Lecture III.)

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Prince D. S. Mirsky, "Russian Literature in the Second Half of the Nineteenth Century." (Lecture II.)

At the London School of Economics and Political Science, Houghton Street, W.C. 5 p.m. Dr. H. Hall, "The Record of Famine in Mediæval England."

Welding Engineers, Institution of, Caxton Hall, Westminster, S.W. 8 p.m. Sir W. Peter Rylands, "The Philosophy of Welding."

FRIDAY, JANUARY 30..Midwives Institute, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 6.30 p.m. Annual General Meeting.

Royal Institution, Albemarle Street, W. 9 p.m. Prof. J. W. Gregory, "The Mountain Structure and Geographical Relations of South-Eastern Asia."

Engineers, Junior Institution of, 39, Victoria Street, S.W. 7.30 p.m. Mr. E. Ambrose, "Notes on High Voltage Electrical Transmission."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 7 p.m. Discussion on "Alternatives to the 'Clash' Type of Change-Speed Gear for Motor Vehicles."

(Yorkshire Centre), at the Brown Firth Research Laboratories, Princess Street, Sheffield. 7.30 p.m. Prof. F. C. Lea, "The Effect of Repetition Stresses on Steels."

University of London, King's College, Strand, W.C. 5.30 p.m. Dr. O. Vocadlo, "The Czechoslovak Language." (Lecture II.)

SATURDAY, JANUARY 31..Royal Institution, Albemarle Street, W. 3 p.m. Dr. E. H. Fellowes, "The Elizabethan Madrigal."

London County Council, at the Horniman Museum, Forest Hill, S.E. 3.30 p.m. Miss M. A. Murray, "The Empire of Egypt."

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FRIDAY, JANUARY 30, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 2nd, at 8 p.m. (Cantor Lecture). V. E. PULLIN, Director, Radiological Research Department, Woolwich, "Radiological Research—A History." (Lecture III).

WEDNESDAY, FEBRUARY 4th, at 8 p.m. (Ordinary Meeting). SIR ERNEST RUTHERFORD, O.M., M.A., D.Sc., F.R.S., "The Stability of Atoms." (Trueman Wood Lecture). SENATORE GUGLIELMO MARCONI, G.C.V.O., LL.D., D.Sc. Chairman of Council, will preside. Tea and coffee will be served in the Library after the meeting.

FRIDAY, FEBRUARY 6th, at 4.30 p.m. (Indian Section). J. T. MARTEN, M.A., I.C.S., "Population Problems from the Indian Census." SIR EDWARD A. GAIT, K.C.S.I., C.I.E., Ph.D., will preside. Tea and coffee will be served in the Library at 3.45 p.m.

SEVENTH ORDINARY MEETING.

WEDNESDAY, 21st JANUARY, 1925. SIR HERBERT JACKSON, K.B.E., F.R.S., in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Artis, Cecil Randolph, Norwich.
Atkinson, Llewelyn B., M.I.E.E., London.
Cunnew, George Arthur, London.
Day, Wilfred Ernest Lytton, London.
Fazl, Dr. Sheikh Abul, Ph.D., LL.D., Kapurthala, India.
Forbes, G. A., Kingston, Jamaica, British West Indies.
Herbert, Desmond A., Brisbane, Australia.
Jones, Owen, Melbourne, Australia.
Lawton, Charles Henry, Warminster, Wilts.

Marshall, F. K., Bombay, India.
Napp, Hermann Richard, London.
Powell, Charles Henry, London.
Sen, Lalit Mohan, London.
Stokes, Henry Gordon, Harrow.
Thomas, Major George Frederick, M.C., Tunbridge Wells.
Williamson, William James, London.

The following Candidates were duly elected Fellows of the Society:—

Field, Major George Kenelm, London.
Mullowney, John James, M.D., Nashville, Tennessee, U.S.A.
Shuttleworth, Alfred, Bury, Lancs.

A paper on "Irish Glass, Old and New," was read by Mrs. Graydon-Stannus. The paper and discussion will be published in a subsequent number of the *Journal.*

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "Recent Progress in the Wool Industries," by Aldred F. Barker, M.Sc., Professor of Textile Industries, University of Leeds, have been reprinted from the *Journal*, and the pamphlet (price 1*s.*) can be obtained from the Secretary, Royal Society of Arts, John Street, Adelphi, W.C.2.

A full list of the lectures which have been published separately and are still on sale can also be obtained on application.

TEN-VOLUME INDEX TO "JOURNAL."

The amalgamated Index to the *Journal of the Royal Society of Arts* for Vols. LXI.-LXX. (1912-1922) is now ready, and can be obtained free by Fellows of the Society on application to the Secretary, Royal Society of Arts, John Street, Adelphi, London, W.C. The price to non-Fellows is 2*s.* 6*d.*

BINDING COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their annual volumes of the *Journal*, cloth covers can be supplied, post free, for 2*s.* each, on application to the Secretary.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

MODERN COLOUR PROBLEMS.

By Louis C. Martin, D.Sc., A.R.C.S., D.I.C., F.R.A.S.,

Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and Technology.

Lecture III.—*Delivered December 8th*, 1924.

The Surface Colours of Material Objects.

The colours of such material objects as are not self luminous arise through their action upon the light energy falling upon them. It may be asked, "What is meant by the 'colour' of such an object as a piece of polished mahogany ?" An eye suitably placed may perceive such an object with a characteristic reddish hue, but in another position the red stimulus may be drowned in a flood of white light reflected from the polished surface. In such a case the colour varies with the direction of view.

In this case it is easy to distinguish between the specular (mirror-like) reflection of the outer surface, and the diffuse reflection of the inner layers. There are, however, many objects, such as paper, in which the transition between reflection of the two types is much more gradual.

The laws of specular reflection are well known, both qualitatively and quantitatively. The partial polarisation which arises in oblique specular reflection at non-metallic surfaces must be borne in mind. It may be of importance in cases of the use of instruments depending on polarisation methods. The phenomena of diffuse reflection are not so well known. Matt white diffusing surfaces are said to be perfectly diffusing if an element of area radiates or reflects light with an apparent candle power proportional to the cosine of the angle made, by the direction of radiation, with the normal to the surface. In a reflecting surface which is perfectly diffusing the distribution of reflected light ought to be entirely independent of the direction of illumination. Very few surfaces reach this ideal performance, though such cases as magnesium oxide (coated on a flat plate by holding it in the smoke of burning magnesium ribbon) offer a close approximation. An easily proved corollary to the law

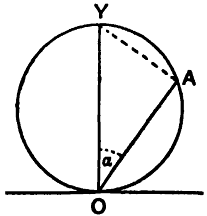

Fig. 16.—Polar curve of perfectly diffuse reflection.

shows that the ideal surface will appear of the same brightness, no matter what the direction of view. Fig. 16 shows a polar curve of reflection in which the vector OA represents the amount of light emitted or reflected per unit of solid angle (the candle power) at an angle α with the normal. In accordance with the above law the locus of A is a circle. Fig. 17 shows a family of polar curves of reflection obtained by Mr. A. P. Trotter[*] from actual experiments on Bristol-board. The angle ε is the angle with the normal made by the illuminating beam, and the nature of the reflection is thus easily seen to be intermediate between the specular and diffuse types. With coloured cards and similar things it happens not infrequently that, just as in the case of the mahogany, the specular portion of the reflection arises largely at the outermost layers, while the selective diffuse reflection occurs at inner layers of the material. Hence not only the reflection, but also the saturation of the colour may vary if the view point is altered with regard to the direction of illumination.

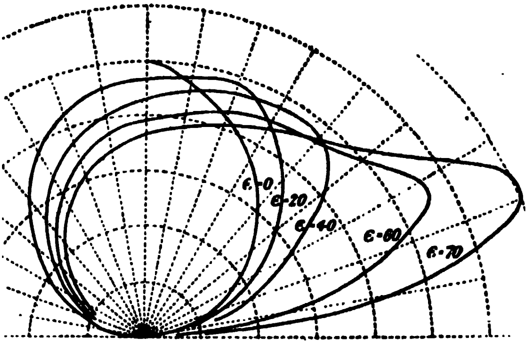

FIG. 17.—Family of polar curves (Bristol-board).

With regard to the apparent relative luminosity of a material surface as compared with that of a perfectly reflecting and diffusing surface under the same conditions of illumination, the ratio between the two may differ considerably from the " reflection coefficient " (*i.e.*, the ratio of the total amount of reflected light to the total amount of incident light) unless precautions are taken to illuminate the surface in a special way. For colorimetric measurements, therefore, it may not be advisable to specify the "reflection coefficient" as a measure of "relative luminosity."

In considerations of this kind there are clearly apparent limits to the application of colorimetry to surfaces. It is necessary to stipulate that surfaces shall be measured and viewed under standard conditions of illumination and viewing, while something must be understood as to the nature of the surface. Considerations of this kind have little or no bearing on the theoretical problem of the measurement of the colour stimulus, but they have the greatest importance with regard to the practical application of colorimetry. I venture to suggest that they are deserving of careful attention.

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[*] Illuminating Engineer, Vol. XII., p. 239. 1919.

A. H. Taylor, in a recent valuable paper* on the measurement of diffuse reflecting factors, cites a number of methods due to Nutting, Little, Rosa, and Luckiesh for the illumination of a test surface when its reflecting power is required. He also describes original methods for the absolute measurement of reflection factors. For spectro-photometric measurements† on the Munsell coloured cards the Bureau of Standards has used a white lined box with electric lamps so placed that either the test sample or a standard magnesium carbonate block could be illuminated by *light of equal intensity from all directions.*

To secure a similar condition Priest‡ has employed a hollow sphere with a matt white interior. An arrangement similar to that of Priest is illustrated in Fig. 18, which is self explanatory. A discussion of the properties of such a sphere is given in modern text books on photometry. A small opaque screen S prevents direct light from the lamp from reaching the test surface. Under these conditions the illumination of the test surface is sensibly uniform from all directions.

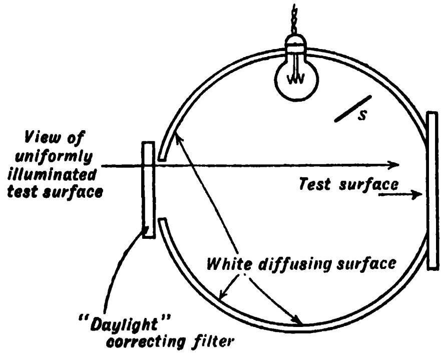
S
View of uniformly illuminated test surface
Test surface
White diffusing surface
"Daylight" correcting filter

FIG. 18.—Use of photometric sphere for illumination of test surface.

A SUGGESTED STANDARD METHOD OF ILLUMINATION.

For colorimetric purposes it should be the aim to imitate the condition of illumination under which the object is ordinarily viewed. If the surface has any specular reflection the eye will instinctively avoid the specularly reflected light. It might be as well, therefore, to adopt the most simple of conditions as the standard of illumination. The illumination for colorimetry might be given by parallel light incident at 45° to the normal, while the direction of view is normal to the surface. This condition would not require elaborate apparatus for its realisation and would be more in harmony with the aim of colorimetry than the use of arrangements suitable for determining the general reflection coefficient of the surface. The condition would lend itself to the use of convenient conical reflectors such as shown in Fig. 19 for the illumination

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* Scientific Paper. Bureau of Standards, No. 391. 1920.

† Technological Papers. Bureau of Standards No. 167.

‡ Journal Opt. Soc. America. Vol. 8, p. 133. 1924.

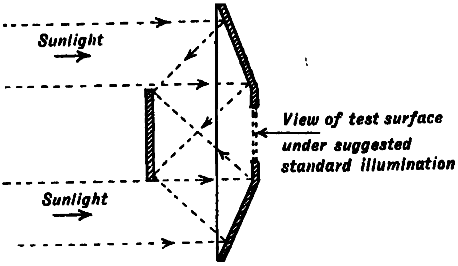

FIG. 19.—Conical illuminating fitting using partially diffusing reflecting surfaces.

of test surfaces by sunlight or by roughly collimated light from a suitable lamp. The reflector might be of glass finely ground on the front face and silvered at the back, thus giving the necessary slight diffusion.

The results of a measurement with this illumination might be called colorimetric brightness, colorimetric saturation, and colorimetric hue, by analogy with the corresponding psychological terms.

QUALITY OF THE LIGHT FOR ILLUMINATION.

The most desirable standard is probably Ives' standard sunlight as described in the first lecture. It is preferable to produce it by rotary dispersion or spectrum template methods.

APPARATUS FOR GENERAL COLORIMETRY.

The apparatus for colorimetric measurements which has been designed up to the present time may be grouped as follows:—

1. Apparatus for monochromatic analysis.
2. Apparatus for trichromatic analysis (additive colour mixture).
3. Apparatus for matching by subtractive colour mixture.
4. Apparatus for sundry other methods, including polarisation colorimeters.

In the first group the apparatus has been designed and used by Abney, Nutting, Priest and others. The use of Abney's colour patch apparatus has already been sketched; Priest's apparatus* for monochromatic analysis is likewise not reduced to the form of a compact instrument. Messrs. Adam Hilger, Ltd., have produced an instrument on lines suggested by Nutting, a diagram of which is given in Fig. 20. The surface giving the colour to be matched is placed at R^1 and its colour appears in the outer part of the field given by the Lummer Brodhun comparison prism B. The central portion of the field

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* J.O.S.A., Vol. 8, p. 133.

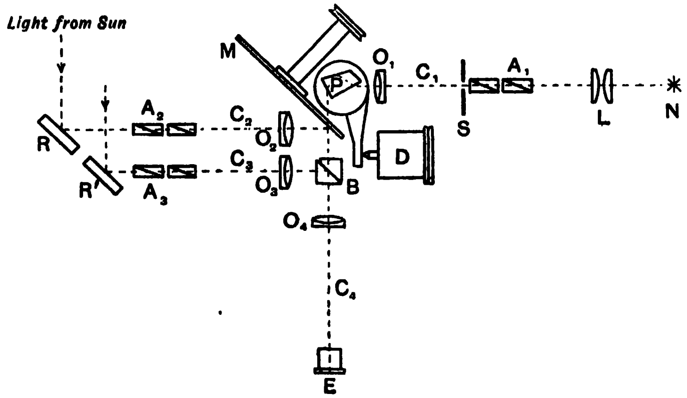

FIG. 20.—The Hilger Nutting Colorimeter.

is illuminated by monochromatic light (produced by the spectroscopic optical system, *i.e.*, the slit S, the collimator lens O_1, the prism P, and the telescope object glass O_4), with which is mixed white light from the reflector R. The relative intensities of the three beams are controlled by pairs of polarising prisms A_1, A_2, A_3. M is a rotating sector in which the opaque portions are glass mirrors, and the "transparent" portions are of clear glass. The reflecting powers (reflection coefficients) of the mirror and clear glass portions are r_2 and r_1 respectively. These can be measured.

Measurements are made as follows: —The sector is turned till one of the clear glass portions is in the field, and the white light from C_2 is then increased to its maximum by rotation of the polarising prism A_2. The prism P is turned by the drum D until the hue in the central portion of the field matches that of the outer portion. The relative intensities of spectral colour and white are then adjusted so that a match in saturation is also obtained, the brightness of the outer field being adjusted to equality by A_3. The drum D will indicate the wave length of the dominant hue.

Let I_S be the portion of the brightness of the central field contributed by the spectral light, and let Lr_1 be the portion contributed by the white light. If L_t be the brightness of the outer field, then

$$L_t = Lr_1 + I_S \qquad (1)$$

In order to obtain the purity of the stimulus the sector is rotated at about 100 revs. per minute and used as a flicker photometer to equalise the brightness of the white beam with that of the spectral beam, the latter being suitably adjusted by the prism A_1, and the collimator C_3 being closed. Hence the relative luminosity of the white and spectral beams can be determined.

The luminosity of the sample as compared with that of a standard white surface (such as magnesium carbonate block) placed in a similar position can be found by successive matches of colour and standard white against the controlled brightness in the centre portion of the field, the collimator C_1 being closed.

APPARATUS FOR MATCHING BY ADDITIVE TRICHROMATIC MIXTURE.*

In the last lecture I described the use of the colour patch apparatus for the synthesis of colour stimuli by the mixture of three monochromatic spectral primaries. Clerk-Maxwell's famous "colour box" could be used for a similar purpose. It is not essential for the production of a varied range of hues that a primary shall consist of radiations of a very narrow range of wave lengths; the approximately monochromatic lights transmitted by, say, red, green, and blue-violet filters can also be mixed in varying proportions to produce stimuli giving a wide range of colours, excluding as before the colours of highest saturation with hues intermediate between those of the colour filters. Satisfactory mixture is difficult without the use of rotating optical parts, although diffusion methods can be employed as in Bawtree's instrument as made by Messrs. Baird and Tatlock, Ltd. The colorimeter invented by F. E. Ives in 1907 employs a rotating wheel of lenses.

For any individual instrument the relative proportions of the primaries in the mixture furnish an arbitrary scale of colour. In order to reduce the indications to the notation of monochromatic analysis a spectro-photometric examination of each colour filter may be made, from the results of which, as previously explained, the proportionate stimulations of the three theoretical primary sensations can be calculated for unit quantity of light from each filter, provided a source of known energy distribution is used. From these results the stimulations of the primary sensations are immediately derived from any set of readings taken on the instrument. Data of this kind have been supplied for the Ives colorimeter, and H. E. Ives has employed the method with success for the investigation of the colour quality of light from illuminants.

One point, which is sometimes lost sight of, is the fact that it is by no means necessary that the primary filters should be of any particular quality. It is better that they shall *just* cover the total range of colour required. For the analysis of illuminants, for example, filters of low saturation should be employed.

The colorimeter of H. E. Ives (reference in footnote) is an example of the use of filters of low saturation in the colour analysis of the light from illuminants. It is illustrated diagrammatically in Fig. 21. S is the source of light, a tungsten lamp with close filaments. The lenses L_1 and L_2 project an image of the source on the diffusing translucent screen G. The screen C between the lenses has apertures screened by red, green, and blue filters (or other colours

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* For descriptions of instruments see the following publications:—F. E. Ives, Jour. Franklin Inst. 164, July, 1907. Bawtree, Journal of Oil and Colour Chemists, November, 1921. Houston, Proc. Roy. Soc. Ed., Vol. XLII., Part 1, p. 75, 1922. H. E. Ives, Journal Opt. Soc. Amer., Vol. 7, p. 243. Guild, Handbook to Exhibition of Scientific Apparatus at Wembley Exhibition, 1924, p. 185. Allen, Journal Opt. Soc. Amer., Vol. 8, p. 339, 1924.

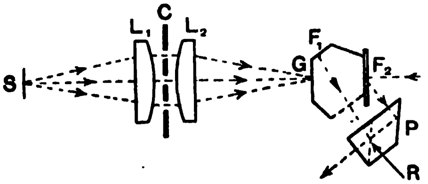

FIG. 21.—Colorimeter of H. E. Ives.

suitable for the special purpose). The hexagonal box, of which G forms one face, is coated matt white on the other interior faces, so that F_1 becomes illuminated by diffused light in which the ratios of red, green, and blue depend on the corresponding relative apertures in the screen C. The prism P, in which the interior reflecting face R is silvered in horizontal strips, permits of the comparison of the apparent colours of faces F_1 and F_2. For the colour analysis of illuminants, F_2 will be given a non-selectively reflecting surface and illuminated by the special source; but any coloured surface of low saturation could be placed at F_2 and illuminated by standard white light for purposes of colour analysis.

APPARATUS FOR COLOUR MATCHING BY SUBTRACTIVE TRI-CHROMATIC MIXTURE.

The Tintometer system of colour matching has already been described, and this system has probably been the most widely used of all. It will be remembered that equal steps in each primary scale correspond to equal steps of density. A short consideration shows that equal steps along a homogenous wedge of absorbing material will give such equal steps of density. Wedges of this kind have been constructed from dyed gelatine for photometric purposes by Sanger Shepherd, and Goldberg's wedge is widely used for photographic sensitometry. I am told that Mr. Lovibond, the inventor of the Tintometer system, carried out some of his early experiments with dyed wedges. The dyes he used proved unstable and he abandoned their use for separate filters of flashed glass.

Comparatively recently *L. A. Jones has brought out a colorimeter operating on the subtractive principle, which is now manufactured by Messrs. Kodak, Ltd. A diagram is given in Fig. 22. C is the Lummer Brodhun comparison

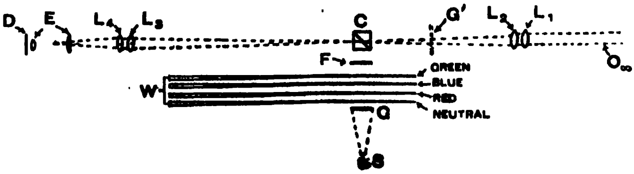

FIG. 22.—Eastman Colorimeter.

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* Journal Optical Soc. America, Vol. IV., p. 420, 1920.

prism, and light from a standard lamp S is made to pass through dyed gelatine wedges, neutral, minus red, minus green, and minus blue, by which almost any desired colour may be produced through relative variation of the positions of the wedges, each of which is furnished with a scale. This filtered light illuminates one part of the field. The filter F is one capable of reducing the light from the lamp S to the visual quality of noon sunlight. The other portion of the matching field is illuminated by an image of the test object projected by the lenses L_1, L_2. One of the most praiseworthy features of the apparatus is that due attention has been paid to the provision of fittings for illuminating the test objects by means of colour corrected lamps. In the case of opaque materials the illumination is at 45° to the normal to the surface, while the view is normal; this is the condition which I have suggested above as a standard for colorimetry. A diagram of this illuminating fitting is given in Fig. 23. It can be fitted to the front of the instrument. Due attention has been given to the colour stability of the wedges, which are said to be satisfactory in this respect, and, moreover, are not exposed to light containing any noticeable intensity of ultra-violet radiation—the predominant agent in fading.

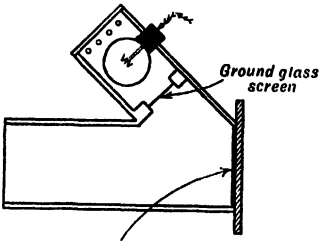

FIG. 23.—Filling for illuminating opaque samples (Eastman Colorimeter accessory).

OTHER COLORIMETERS.

Time will not permit of the full description of the colorimeter of Arons (the Kromskop),* which employs the colours produced by plates of quartz when viewed between polarising prisms, for matching the test colours. There can be no doubt that this method, like those others which do not rest on the use of arbitrarily coloured objects, has certain clearly marked advantages which may compensate for the unavoidable complication of the reduction of its indications to terms of monochromatic analysis.

POSSIBLE ACCURACY OF COLORIMETRIC MEASUREMENTS.

Careful measurements on the difference limen of spectral colour contrast show that the difference of wave length necessary to cause a perceptible colour change varies between .0015μ to .004μ in the various parts of the spectrum between .44μ and .65μ. In the extreme violet and red the values of the limen rapidly increase. Abney and others have maintained that truly monochromatic regions exist at each end of the visible spectrum. This difference limen for "dominant hue perception" naturally increases greatly with decreasing saturation, but I am not aware of any adequate experimental work bearing on the subject.

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*Ann. d. Phys. 33, p. 799, 1910. Ann. d. Phys. 39, p. 545, 1912.

The least perceptible steps in the de-saturation of a pure hue have been investigated by several experimenters. The noticeable change δW in the amount of white in a stimulus consisting of W white and V hue luminosities, where

$$W + V = 1,$$

varies from $\delta W = .05$ when V is nearly 1, to $\delta W = .02$ when W is nearly 1.

Experiments on the difference limen for "brightness" have shown that the just perceptible variation of brightness is of the order of 1.6% to 2% under best conditions, but this increases when the absolute brightness of the matching field becomes too low or too high.

Figures of the kind thus quoted are valid for colour matches in closely touching matching fields subtending angles of 2° to 3°, at least, to the eye. Differences of colour perception are most easy under these conditions, provided the illumination is adequate, and measurements thus made are likely to register smaller differences than can be perceived in ordinary "colour matching" with fabrics, pigments, and the like, without instrumental aid. The provision of a proper matching field in the instrument should be insisted upon, or failure is easily possible. It will take all the attention and skill to obtain correct and adequate colour matches.

COLORIMETERS OF LIMITED RANGE.

There are a number of methods in chemistry which involve colour comparisons, but usually the range of colour involved is only of the type encountered when the thickness of an absorbing material is increased or the concentration of a solution is varied. The law of diminution of the intensity of "parallel" monochromatic radiation caused by passage through a thickness *t* of homogenous absorbing material may be written :—

$$I = I_0 e^{-\alpha t},$$

Hence :—Density $= \log_e \frac{I_0}{I} = \alpha t =$ absorption coefficient × thickness.

If it is necessary to allow for reflection effects at the boundaries then a factor $(1-\beta)^2$ has to be introduced, where β is the reflection coefficient; then

$$I = I_0 (1-\beta)^2 e^{-\alpha t}$$

and the density is increased by $2 \log (1-\beta)$. The law holds for homogenous light, but α (and also β though to a much smaller extent) vary in general with the wave length. Should the concentration of a solution be increased, then

α is proportional to the mass of solvent dissolved in unit volume of the solution, but the law sometimes ceases to be valid for high concentrations. The modified law, due to Beer, is $I=I_0 e^{-c\alpha_0 t}$ where c is the concentration.

The essence of such colorimetric practice is that estimations of relative *concentration* may thus be made by finding the *thickness* of the layer of a standard solution necessary to give the same colour. White light is usually employed. The apparatus used for this purpose varies from a few simple tubes with flat ends to the useful instruments of the Duboscq type (Fig. 24). The essence of the optical action of these is the telecentric stop S, which is placed in the principal focus of the lens L_1 and selects for transmission only those rays passing in parallel to the axis. These rays, therefore, pass through the absorbing tubes as a parallel beam. The lens L_2 is to allow the dividing edge of the field to be brought clearly into view without strain on the accommodation, but it does not otherwise influence the optical effect; C_1 and C_2 are equal cylinders of clear glass. In the instrument by Messrs. Hawksley and Sons, the lens L_2 is omitted, the tube holding the stop and the lens L_1 being adjustable for focussing purposes.

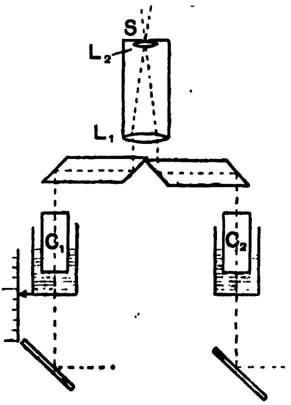

FIG. 24.—Optical action of Duboscq Colorimeter.

THEORY OF MATCHING.

In one tube is found a test solution of unknown concentration c_1 which is compared with a standard solution of known concentration c_0. It is found that a depth or thickness t_1 of the unknown solution produces the same effect in the comparison field as a depth t_0 of the standard. Assuming that the reflection losses, etc., are identical, then

$$I_0\,(1-\beta)^2 e^{-c_1\alpha_0 t_1} = I_0\,(1-\beta)^2 e^{-c_0\alpha_0 t_0}$$

from which $$c_1 = c_0\,\frac{t_0}{t_1}$$

If the solvent is coloured then complications arise. The case may be considered by adding a term to the power of *e* in the above equation to represent the absorption of the solvent. Monochromatic light would be advisable for experiment in such a case.

Snell* in his book on colorimetric analysis gives particulars of a great many chemical determinations which are carried out rapidly and conveniently by this method. Seven methods for iron, seven for copper and eight for gold, are described, as well as numerous other applications to carbon in steel, lead, bismuth, and arsenic, aluminium, chromium and many other substances. The method of colorimetric determination of ammonia with Nessler's reagent is well known for convenience and accuracy. A good bibliography of colimetric and nephelometric methods is given in the catalogue of the Klett Manufacturing Company of New York.

NEPHELOMETERS.

The scattering of light by particles suspended in a transmitting medium has been made the basis on which photometric or colorimetric methods have been applied for the study of precipitates, colloidal substances and the like. The pioneer in this direction was Richards, who devised an instrument for studying cloudy solutions which he termed a nephelometer (νεφε′λη, a cloud). A résumé of the development of the subject is given by Thorpe in the " Dictionary of Applied Chemistry." The late Lord Rayleigh examined mathematically the scattering of light by very fine particles and gave an expression which has been widely used. Nevertheless, the ordinary scattering of light by slightly cloudy solutions with fairly coarse suspensions (usually known as the " Tyndall effect " from Tyndall's famous experiments on the subject) may be largely due to reflection effects at the boundaries of the particles ; the "blue" colour selective effect characteristic of very fine particles rarely appears. In the most widely used modern nephelometer, that due to Kober, a vertical tube containing the turbid solution is illuminated by a parallel beam of uniform intensity incident perpendicular to the length of the tube. Kober's nephelometer is shown in Fig. 25. Fig. 26 is to illustrate the theory. The quantity of light δF scattered into a vertical direction by a thin layer of liquid of thickness δt at a depth t below the upper boundary of the turbid medium may be written,

$$\delta F = Kc\delta t$$

Where K is a constant, and c is the concentration (in this case proportional to the number of particles per unit volume of the liquid, assuming uniform size). The light suffers loss in transmission through the layers of liquid above the one under consideration, and the amount arriving at the upper boundary from the elementary layer may be written

$$\delta F^1 = Kc\delta t e^{-\alpha t}$$

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* Colorimetric Analysis. D. Van Nostrand Co., New York.

Amer. Chem. Jour., 1904, 31, 235.

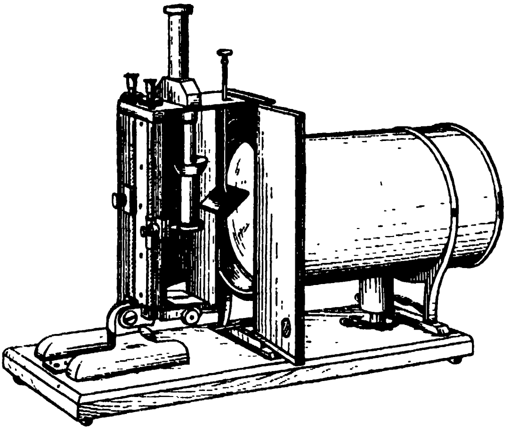

FIG. 25.—The Kober Nephelometer.

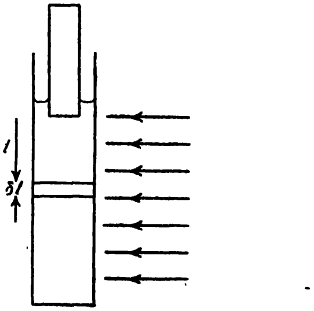

FIG. 26.—Theory of Kober Nephemoleter.

The total amount of vertically scattered light contained in a hypothetical vertical beam (in the actual instrument this is picked out by a telecentric stop at the focus of the observation system) can now be obviously obtained from the integral $F^1 = \int_0^T Kce^{-\alpha t} dt.$

It should, however, be noticed that α is clearly connected with c, and for a first approximation we may write $\alpha = c\alpha_0$

hence $F = \int_0^T Kce^{-c\alpha_0 t} dt = \frac{K}{\alpha_0}\left(1 - e^{-c\alpha_0 T}\right)$

The brightness of the field under the usual instrumental conditions is proportional to F. Hence when a comparison of the liquid for test is made with the similar liquid of standard concentration c_0 (which requires a depth T_0, say, to give the same luminosity in the field) we have

$$\frac{K}{\alpha_0}\left(1 - e^{-c\alpha_0 T}\right) = \frac{K}{\alpha_0}\left(1 - e^{-c_0\alpha_0 T_0}\right)$$

By this simple theory, therefore, we find $c\alpha_0 T = c_0\alpha_0 T_0$ or $c = \frac{c_0 T_0}{T}$.

The formula, first obtained by Kleinmann from experimental results, is not very satisfactory when the cloudiness of the liquid is great. Kober's suggested empirical expression takes the form

$$t = t_0 \frac{c_0}{c} \left\{ 1 + \left(1 - \frac{c}{c_0} \right) k \right\}$$

where k is the nephelometric constant, which may be evaluated by taking readings of one or two known dilutions of the standard. A simpler method is to plot a curve from these results and determine the unknown concentrations from experimental results by the aid of the graph. The simple theory given above takes no account of the fact that through diffusion effects some of the light at first scattered sideways may finally become part of the vertical beam. Papers dealing with these expressions and the theory of the Kober instrument have been published by Wells* and Lednicky†.

The side illumination is not the only available means by which the nephelometric measurements may be carried out. It is possible to view from the side while a collimated beam of light passes through the vertical tube.

Let the intensity of the beam immediately after entering the medium be I_0, then the intensity after traversing a thickness t will be $I_0 e^{-c\alpha_0 t}$ (assuming that no scattered light is contributing intensity to the vertical beam after diffusion and reflection). The amount of light scattered into a direction perpendicular to the beam will be proportional to the intensity of the beam and also to the concentration. Hence in the case of comparison with a standard, the equation may be written

$$KcI_0 e^{-c\alpha_0 t} = Kc_0 I_0 e^{-c_0 \alpha_0 t_0}$$

Where the right hand member represents the luminosity at a standard height t_0 in a tube filled with a liquid of standard concentration c_0. From this equation we obtain :—

$$\log_e \frac{c}{c_0} = \alpha_0 (ct - c_0 t_0)$$

A graphical solution of the problem, on the lines indicated above, is the most satisfactory, but the equation may be useful in drawing the curve connecting " concentration " and " height at which a standard luminosity is found."

A nephelometer on these lines has been used by Professor A. F. C. Pollard, of the Optical Engineering Department, Imperial College, and an improved model has recently been described by Mr. R. Kingslake, of the same department, who has kindly brought it here for exhibition. In this instrument two tubes are employed illuminated as shown diagrammatically in Fig. 27. One of these can be given a vertical movement by a rack and pinion so that the luminosity at various measured heights in the movable tube can be compared, by the aid of a suitable comparison prism, with the luminosity at a standard

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* Jour. Amer. Chem. Socy., XLIV., p. 267, 1922.

† Kolloid Zeit. XXXII., p. 12, 1923.

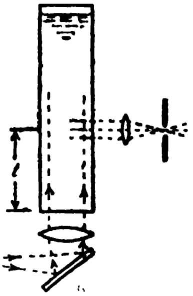

FIG. 27.—Nephelometer with Vertical beam.

height in the fixed tube. The movable tube can be filled with a permanent standard solution, or replaced by a rod of slightly opalescent glass. Professor Pollard has used his instrument with success for detecting and estimating the minute traces of oxides of nitrogen arising in the slow but dangerous decomposition of explosives, such as gun cotton. A solution was prepared by adding 20 ccs of $\frac{N}{10^3}$ NaOH very slowly to 80ccs of $\frac{N}{10}$ $AgNO_3$, which produces a slightly cloudy liquid. This was used to fill the standard tube of the instrument, and a calibration curve was first obtained by using this liquid in several dilutions in the comparison tube, for which the necessary height *l* was obtained which gave the standard luminosity at each stage of concentration.

A sample of the gun cotton to be tested was dried over H_2SO_4 for six days. Pure dry air bubbled into the comparison tube produced no change in the concentration, but when such air was passed over a sample of three grams of the gun cotton an immediate change in the concentration was detected and measured by the nephelometer. The action ceased at the end of an hour, but could be restarted by introducing a fresh sample of partially stabilized gun cotton into the air current. It would have been practically impossible to detect the decomposition products by ordinary chemical means.

This brief description will serve to indicate the great sensitiveness of methods of this kind, a sensitiveness which can be greatly increased by methods similar to those of the ultra-microscope, but using a microphotometer system in place of the observing microscope. There is an immense field for exploration in this subject. The adequate study of the colours of material objects must include the study of all such effects as "scattering," "diffuse transmission" and the like. No apology for introducing the topic of nephelometry need be made.

LIMITATIONS OF COLORIMETRIC METHODS.

The comparator or true substitution methods of limited range colorimetry and nephelometry are independent of the possible abnormality of the colour vision of an observer, and this is true for the ordinary methods of visual spectrophotometry.

The methods of general colorimetry are, however, very dependent on a normal state of colour vision. Although any one abnormal individual would very likely make consistent measures by trichromatic and monochromatic analysis, yet his measures would not be identical with those of a normal person. About four per cent. of the population suffer from more or less marked colour blindness, but there is at present little evidence to guide us in obtaining an idea as to how far the 96% more or less normal people would be likely to differ amongst themselves. It is well known that they exhibit certain variations in trichromatic additive matches. How far would the results differ when each individual reduced his results (with the aid of his own sensation curves) to terms of monochromatic analysis ?

These considerations only apply, however, when measurements are wanted for transmission between different individuals. There are many purposes in commerce, such as the grading and standardisation of products in the laboratory, where only one individual needs to make and use such measurements. Here, again, we are independent of *slight* abnormality, but diminished sensitiveness to hue changes is always a disadvantage.

Roughly speaking, a colour match made by a normal observer remains valid after retinal fatigue by coloured light, but the accuracy of fresh matches would be diminished. Every attention must be made to secure proper observational conditions. For photometry with a hue-less field, nephelometry and the like, my own suggestion* of surrounding the matching field with a wide border of equal brightness will result in increased accuracy of settings and might be adopted with advantage.

GENERAL LINES OF PROGRESS.

Returning to the consideration of the subject of general colorimetry, there is no doubt that progress is being rapidly made. The study of the action of the visual receptor mechanism, its fatigue, adaptation, and response characteristics, is placing the operations of photometry and colorimetry on a new and sounder basis, so that future experiments will be carried out with more precise conditions. A very great deal of work done in the past has been useless, because of the failure to control and specify the exact circumstances under which observations were made.

As regards colorimetry, far more information is required regarding the nature of the results which would be obtained by different persons in deriving the three colour " sensation curves." Also, far more experience in the reduction of colorimetric results obtained by different methods ought to be obtained. There are many points (such as the question of the addition of luminosities in the presence of differing hues) which require more experiment.

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* Proc. Roy. Soc. A. Vol. 104, p. 302.

Nothing but experience can teach how far the practice of general colorimetry will affect commerce and industry, but there seems to be a great number of openings. Sufficient has been said in the present lectures to show that the application of scientific methods to colour problems is resulting in many important developments. The saving of time possible by the use of artificial daylight must already be very great.

While important developments are taking place in the study of the mechanism of colour vision (as, for instance, Allen's experiments on retinal reflex actions) progress in the more utilitarian study of colour measurement is also being made. This requires close attention to the action of material substances on light, and I have tried in the present lecture to bring out the importance of the study of the reflection (specular and diffuse), transmission and scattering of light. It is with such thoughts in mind that I have given some little attention to limited range colorimetry and nephelometry.

It only remains to express my sincere thanks for the attention you have given me and to express the hope that these lectures may do something to create renewed interest in a subject of no little importance, but which is only one of the rapidly developing sciences which may be generally grouped under the title of Applied Optics.

My sincere thanks are due to the following firms who have exhibited apparatus at the lectures :—

		Exhibit.
Lecture I.	Messrs. Lamplough Daylamp, Ltd.	The Lamplough Daylamp and the Rest Lamp.
,, II.	Messrs. Tintometer, Ltd. ..	The Tintometer.
,, III.	Messrs. Hawksley & Sons, ..	The Duboscq Colorimeter.
,, ,,	Messrs. Adam Hilger, Ltd. ..	The Hilger-Nutting Colorimeter.
,, ,,	Messrs. Adam Hilger, Ltd. ..	The Hilger-Nutting Spectrophotometer.
,, ,,	Messrs. Kodak, Ltd. (Wratten Division)	The Eastman Colorimeter.

OBITUARY.

William Whitaker, F.R.S.—Mr. William Whitaker, who died at Croydon on January 15th, at the age of 88, was elected a member of the Royal Society of Arts in 1886. In 1890 he read a paper on "Coal in the South-East of England," for which he received the Society's silver medal; he frequently took part in discussions here, and until quite recently his venerable figure was a familiar sight in the Society's House.

William Whitaker was born in London in 1836, and educated at St. Albans Grammar School and University College, London. He was on the staff of the Geological Survey of England from 1857-96, and subsequently he practised as a consulting engineer, his speciality being water supply from the deep borings in the

London area. He was the author of many Geological Survey maps and memoirs, and of numerous papers read before the Geological and other Societies, while his two-volume work on the Geology and Underground Water of the London Basin is a standard contribution to the subject. He was elected a Fellow of the Royal Society in 1887. He was also a president of the Geological Society from whom he received the Wollaston, Murchison and Prestwich medals.

NOTES ON BOOKS.

MOTOR CAR AND COACH PAINTING : FOR PRIVATE, COMMERCIAL AND MASS OUTPUT. By Charles E. Oliver. Edited by Arthur Seymour Jennings. London: W. R. Howell and Company, 42 Theobald's Road, W.C. 1. £1 8s. 6d.

This handsome and fully illustrated quarto is essentially a book of the present day, and the first impression on glancing through it is the surprising changes that have taken place in Coach Painting since the advent of the modern motor car.

Let us suppose that a reader opens the book at p. 105, where he is introduced to the "Three-day Process" in mass production as applied to the painting of from 200 to 300 fine car bodies per week. Here he may read of drying rooms heated to appropriate temperatures, "the first one at 160° F. for drying rust-proof primings, down to 100° F. in the last one, intended for finishing coats of varnish." As all through the book, the reader will find illustrative plates easily to hand: when reading p. 105 he has only to turn over the leaf on his left to see a good photographic plate showing a device for cleansing and heating the air of varnishing rooms; if, on the other hand, he has turned over two leaves on his right he will face p. 108 and plate XVII. The lower portion of the page and the plate give him sketch details of workshop planning. He will see how a main rail system, deeply recessed, carries transverse trollies by which motor cars or car-bodies can be quickly taken in or out of the ambit of special treatment. For example, six tranverse trollies may stop opposite six spraying recesses. Here the trained human elements step in; spray-pistol in one hand, aided by electric control of the turntable, the operator may lay the first coat in half a minute. Matters incidental to modern intensive methods culminate in plate XXXIII., which illustrates the flow-on method of painting, with drainage, pump and return system.

Everyday practical details of the kind having special interest for the lone worker are described and illustrated in every section of the book; these matters being easily accessible by a good index. On p. 32 there are hints on preparing the surface, whether the work is of the cheap class or otherwise, and opposite is a plate which illustrates two methods of rubbing down, also the use of the brush in varnishing. Filling in and surfacing in their broad aspects are considered on pp. 14-15, and on turning over forward there are five illustrations and text. Again turning over we have text and illustrations.

Commercial matters are carefully considered from various standpoints, but a commercial problem not touched on is the production of so full and remarkable a book at the above-stated price.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock, unless otherwise announced:—

FEBRUARY 4.—SIR ERNEST RUTHERFORD, O.M., M.A., D.Sc., F.R.S., *Trueman Wood Lecture*, "The Stability of Atoms." SENATORE GUGLIELMO MARCONI, G.C.V.O., LL.D., D.Sc., Chairman of the Council will preside.

FEBRUARY 11 (at 4.30 p.m.).—SIR J. FORTESCUE FLANNERY, Bt., Past-President of the Institute of Marine Engineers, "The Diesel Engine in Navigation." LORD BEARSTED, LL.D., will preside.

FEBRUARY 18.—J. S. OWENS, M.D., Assoc. M.Inst.C.E., F.G.S., Superintendent, Advisory Committee on Atmospheric Pollution, Air Ministry, Meteorological Office, "Modern Atmospheric Conditions." SIR NAPIER SHAW, LL.D., Sc.D., F.R.S., will preside.

FEBRUARY 25.—SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., "The Power of Internal Combustion Engines for Motor Cars." THE HON. SIR CHARLES A. PARSONS, K.C.B., LL.D., D.Sc., F.R.S., will preside.

MARCH 4.—PROFESSOR W. E. S. TURNER, O.B.E., D.Sc., F.Inst.P., Department of Glass Technology, University of Sheffield, "The Modern Production of Sheet-Glass."

MARCH 11.—EMILE CAMMAERTS, "The Restoration of Public Buildings in Belgium." VISCOUNT BURNHAM, C.H., LL.D., will preside.

MARCH 18.—CLAUDE N. FRIESE-GREENE, "Colour Cinematography."

MARCH 25.—HENRY G. DOWLING, "Wall-papers."

APRIL 1.—WILLIAM NUNN, "Siam."

Dates to be hereafter announced :—

MAJOR-GENERAL SIR WILLIAM SEFTON BRANCKER, K.C.B., Director of Civil Aviation, Air Ministry, "Commercial Aviation."

SIR SAMUEL INSTONE, "The Thames Passenger Services."

CEDRIC CHIVERS, "Bookbinding."

C. R. PEERS, C.B.E., F.S.A., Chief Inspector of Ancient Monuments and Historic Buildings, "The Development of Ornament."

LIEUT.-COLONEL ANDREW BALFOUR, C.B., C.M.G., M.D., (Edin.), B.Sc., D.P.H., F.R.C.P.E., "The Trend of Modern Hygiene."

DAVID GREENHILL, "Colour Printing."

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

FEBRUARY 6.—J. T. MARTEN, M.A., I.C.S., "Population Problems from the Indian Census." SIR EDWARD ALBERT GAIT, K.C.S.I., C.I.E., Ph.D., will preside.

MARCH 6.—SIR HENRY SHARP, C.S.I., C.I.E., M.A., "The Development of Indian Universities."

MAY 8.—SIR GILBERT T. WALKER, C.S.I., M.A., F.R.A.S., Sc.D., Ph. D., F.R.S., "Indian Meteorology."

JUNE 12.—BRIGADIER-GENERAL SIR PERCY M. SYKES, K.C.I.E., C.B., C.M.G., "The Heart of Asia and the Roof of the World."

Date to be hereafter announced :—

SIR ALFRED CHATTERTON, C.I.E., Assoc.M.Inst.C.E., "The Industries of the Mysore State."

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons, at 4.30 o'clock, unless otherwise announced :—

FEBRUARY 24.—R. H. BRACKENBURY, Member of the Empire Cotton Growing Corporation Mechanical Transport Sub-Committee, "Transport in Tropical Africa." MAJOR-GENERAL SIR ERNEST D. SWINTON, K.B.E., C.B., D.S.O., R.E., will preside.

JUNE 18 (Thursday).—HON. W. G. A. ORMSBY-GORE, M.P., Under-Secretary of State for the Colonies, "East Africa."

Date to be hereafter announced :—

Lord Blyth, "Penny Postage and Postal Communications Generally."

DOMINIONS AND COLONIES AND INDIAN SECTIONS. (JOINT MEETING).

Date to be hereafter announced :—

Lord Stevenson, G.C.M.G., (Chairman, Standing Committee of British Empire Exhibition), "The British Empire Exhibition." Sir Charles Campbell McLeod, Bt. (Chairman of the Finance Committee of the Exhibition) will preside.

CANTOR LECTURES.

Monday evenings, at 8 o'clock :—

V. E. Pullin, Director, Radiological Research Department, Woolwich, "Radiological Research—A History."

Lecture III.—February 2.—Early applications of X-rays. Development of medical uses. Modern applications. Physiological dangers. Necessity for protection.

Walter Rosenhain, B.A., B.C.E., D.Sc., F.R.S., Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory "The Inner Structure of Alloys." Three Lectures. February 16, 23, March 2.

HOWARD LECTURES.

Monday evenings, at 8 o'clock :—

Professor John Samuel Strafford Brame, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, "Motor Fuels." Three Lectures. April 20, 27, May 4.

MEETINGS OF OTHER 'SOCIETIES DURING THE ENSUING WEEK.

Monday, February 2.. Chemical Industry, Society of, (London Branch), at the Chemical Society, Burlington House Piccadilly, W. 8 p.m. (1) Mr. E. J. Lush, "Kinetics of Hydrogenation." (2) Messrs. C. O. Condrup and E. W. Smith. "Tar Distillation by means of the T.I.C. (Lead Bath) Process."

British Architects, Royal Institute of, 9, Conduit Street, W. 8 p.m. President's Address to Students and Presentation of Prizes.

Textile Institute, Clothworkers' Hall, 41, Mincing Lane, E.C. 5.45 p.m. Mr E. B. Fry, "Textile By-products, Mungo and Shoddy."

Farmers' Club, at the Surveyors' Institution, 12 Great George Street, S.W. 4 p.m. Prof. A. F. Barker, "British Wools, their Growth and Manufacturing Possibilities."

Electrical Engineers, Institution of (Western Centre), Plymouth 6 p.m. Mr. H. Marryat, "Electric Passenger Lifts."

Royal Institution, Albemarle Street W. 5 p.m. General Meeting.

Economics and Political Science, London School of, Houghton Street, Kingsway, W.C. 5 p.m. Dr. E. B. Behrens, "International Problems of Industry." (Lecture III.)

University of London, University College, Gower Street, W.C. 5 p.m. Prof. G. E. Smith, "The Anatomy and Physiology of the Sympathetic Innervation of the Striated Muscle" (Lecture III).
At King's College, Strand, W.C. 5.30 p.m. Rev. C. F. Rogers, "Ecclesiastical Music." (Lecture II).
5.30 p.m. Mr. H. W. Steed, "The Power of Historical Memory."
5 p.m. Dr. J. A. Hewitt, "Carbohydrate Metabolism." (Lecture III).

Tuesday, February 3... Petroleum Technologists, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 5.30 p.m. Dr. H. I. Waterman and Mr. J. N. J. Perquin, "Decomposition of Paraffin Wax at 450 degrees Centigrade in presence and in absence of Hydrogen under High Pressure"

Zoological Society, Regent's Park, N.W. 5.30 p.m. (1) Dr. Doris R. Crofts, "The Comparative Morphology of the Cæcal Gland (Rectal Gland) of Selachian Fishes." (2) Mr. S. Hirst, "Descriptions of New Acari, mainly parasitic on Rodents." (3) Prof. O. Fuhrmann, and Dr. J. G. Baer, "Zoological Results of the Third Tanganyika Expedition conducted by Dr. W. A. Cunnington, 1904-1905.—Report on the Cestoda" (4) Mr. A. Loveridge, "On *Natrix olivacea* Peters (Reptilia), from Pemba Island, and other Notes." (5) Mr. R. I. Pocock, "The External Characters of an American Badger (*Taxidea taxus*) and an American Mink (*Mustela vison*) recently exhibited in the Society's Gardens." (6) Mr. E. P. Allis, Jun., "On the Origin of the V-shaped Branchial Arch in the Teleostomi." (7) Mr. R. I. Pocock, "Additional Notes on the External Characters of some Platyrhine Monkeys."

Metals, Institute of (Local Centre), at the Chamber of Commerce, New Street, Birmingham. 7 p.m. Discussion on, "Metal Melting."
(Local Centre). Armstrong College, Newcastle-on-Tyne. 7.30 p.m. Open Discussion.

Marine Engineers, Institute of, 85, The Minories, E. 6.30 p.m. Paper on "The Treatment of Boiler Feed Water."

Royal Institution, Albemarle Street, W. 5.15 p.m. Dr. H. R. Hall, "The Connexion and Relations of the Prehistoric Greek and Ancient Egyptian Civilisations." (Lecture II).

Electrical Engineers, Institution of, (N.-Western Centre), at the Engineers' Club, Albert Square, Manchester. 7 p.m. Mr. A. B. Mallinson "Justifiable Small Power Plants."

University of London, University College, Gower Street W.C. 5.30 p.m. Mr. N. H. Baynes, "Som Aspects of Byzantine Civilisation." (Lecture I).

5.30 p.m. Mr. W. J. Perry, "The Beginnings of Civilisation."

5.30 p.m. Miss Hilda D. Oakley, "The Religious Ideas of Plato."

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia from 1861." (Lecture III).

At the Middlesex Hospital Medical School, Cleveland Street, W. 5 p.m. Mr. E. C. Dodds, "The Chemistry of the Internal Secretions." (Lecture I).

Wednesday, February 4..Public Analysts, Society of, at the Chemical Society, Burlington House, Piccadilly, W. 8 p.m. (1) Annual General Meeting, Presidential Address. (2) Dr. D. Hooper, "Cinchonine as a Tannin Precipitant with Special Reference to the Analysis of Cutch and Gambier." (3) Mr. C. A. Mitchell, "The Examination of Charred Documents." (4) Mr. H. R. Ambler, "The Absorption of Carbon Monoxide in Gas Analysis."

British Academy, at the Royal Society, Burlington House, Piccadilly, W. 5 p.m. Prof. M. W. Maccallum "The Dramatic Monologue in the Victorian Period."

United Service Institution, Whitehall, S.W. 3 p.m. Colonel D. J. C. K. Bernard, "The Crossing of Rivers in Warfare."

Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

Economics and Political Science, London School of, Houghton Street, Aldwych, W.C. 5 p.m. Mr. H. P. Shapland, "The Principles of Design Applied to Furniture."

Electrical Engineers, Institution of, (Wireless Section), Savoy Place, Victoria Embankment, W.C. 6 p.m. Messrs. L. B. Turner and F. P. Best, "The Optimum Damping in the Auditive Reception of Wireless Telegraph Signals."

University of London, University College, Gower Street, W.C. 5.30 p.m. Mr. R. E. Flower, "The Use of Libraries:—Collections and Manuscripts."

6 p.m. Mr. H. Higgs, "The Financial Problems of Europe." (Lecture III). Germany.

At King's College, Strand, W.C. 5.30 p.m. Prof. A. Mawer, "The Viking Age, A.D. 500-800."

At St. Bartholomew's Hospital Medical College, 6, Giltspur Street, E.C. 5 p.m. Prof. C. L. Evans, "The Physiology of Plain Muscle." (Lecture IV).

Thursday, February 5..Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. Dr. J. H. Jeans, "Electrical Forces and Quanta." (Kelvin Lecture).

Royal Institution, Albemarle Street, W. 5.15 p.m. Sir William Bragg, "The Properties and Structure of Quartz." (Lecture II).

Linnean Society, Burlington House, Piccadilly, W. 5 p.m. (1) Dr. G. P. Bidder, "Growth and Death: a Discussion." (2) Dr. J. B. Davy, "The Geographical Distribution of the arborescent vegetation of Subtropical South Africa."

Chemical Society, Burlington House, Piccadilly, W. 8 p.m.

Aeronautical Society, 7, Albemarle Street, W. 5.30 p.m. Air-Commodore C. R. Samson, "The Operation of Flying Boats in the Mediterranean."

Victoria and Albert Museum, South Kensington, S.W. 6 p.m. Mr. E. R. D. Maclagan, "Italian Sculpture."

Mechanical Engineers, Institution of, (Midland Branch), at the Queen's Hotel, Birmingham. 6.30 p.m. Mr. D. Adamson, "The Economics of Engineering"

(Glasgow Branch). At the Royal Technical College, Glasgow 7.30 p.m. Mr. J. Biggam, "Methods of Determining the Properties of Steam."

(Western Branch). At the Merchant Venturers' Technical College, Bristol. 7 p.m. Mr. L. A. Legros, "Traction Across Rough and Roadless Country."

University of London, University College, Gower Street, W.C. 5 p.m. Dr. A. S. Parkes, "The Physiology of Reproduction." (Lecture III).

5.30 p.m. Senator Prof. A. Cippico, "Il Senso Panico Nella Poesia di Gabriele d'Annunzio." (In Italian).

5.15 p.m. Prof. J. E. G. de Montmorency, "African Customary Law, with special reference to Early Egyptian Law" (Lecture III).

At King's College, Strand, W.C. 5.30 p.m. Lieut.-Comdr. A S Elwell-Sutton, "The Civilisation of China."

5 p.m. Dr. R. B. McKerrow, "Bibliographical Notes for Students of English Literature." (Lecture I).

6.30 p.m. Dr. O. Vocadlo, "Czech Civilisation." (Lecture IV).

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Prince S. D. Mirsky, "Russian Literature in the Second Half of the XIX. Century." (Lecture III).

At Middlesex Hospital Medical School, Cleveland Street, W. 5 p.m. Mr. E. C. Dodds, "The Chemistry of the Internal Secretions." (Lecture II).

Friday, February 6..Royal Institution, Albemarle Street, W. 9 p.m. Dr. R. W. Chambers, "The Earliest Recorded Kings of the English."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 6 p.m. Mr. J. B. Dahlerus "Anti-Friction Bearing Applications for Heavy Duty."

(Midland Branch, Graduates' Section.) At the Chamber of Commerce, New Street, Birmingham. 7.30 p.m. Mr. R. B. A. Ellis, "James Watts."

Philological Society, University College, Gower Street, W.C. 8 p.m. Mr. N. W. Thomas, "The Sudanic Languages."

Aeronautical Engineers, Institution of, at the Engineers' Club, Coventry Street, W. 6.30 p.m. Mr. H. L. J. Hinkler, "Flying in Australia."

Engineers, Junior Institution of, 39, Victoria Street, S.W. 7.30 p.m. Mr. E. G. Herbert, "The Measurement of Hardness and Allied Properties of Metals."

Auctioneers' and Estate Agents' Institute, 29, Lincoln's Inn Fields, W.C. 7.30 p.m. Mr. F. Colebrook, "Some Points in Machinery Valuations."

University of London, at King's College, Strand, W.C. 5.30 p.m. Mr. N. B. Japson, "The Early History of the Stars." (Lecture I).

Geologists' Association, University College, Gower Street, W.C. 7.30 p.m. Annual General Meeting. 8 p.m. Address by the President, Mr. H. Dewey, "The Mineral Zones of Cornwall."

Saturday, February 7..Royal Institution, Albemarle Street, W. 3 p.m. Dr. E. H. Fellowes, "The Elizabethan Ayre."

London County Council, at the Horniman Museum, Forest Hill, S.E. 3.30 p.m. Mr. R. P. G. Denman "The Development of Modern Radio Communication."

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No. 3768 VOL. LXXIII.

FRIDAY, FEBRUARY 6, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

WEDNESDAY, FEBRUARY 11th, at 4.30 p.m. (Ordinary Meeting.) SIR J. FORTESCUE FLANNERY, Bart., D.L., M.Inst.C.E., Past-President of the Institute of Marine Engineers, Past-President of the Society of Consulting Marine Engineers, " The Diesel Engine in Navigation."

LORD BEARSTED, LL.D., a Vice-President of the Society, will preside.

Tea and coffee will be served in the Library at 4 p.m.

DOMINIONS AND COLONIES SECTION.

TUESDAY, JANUARY 27TH, 1925; SIR HALFORD JOHN MACKINDER, M.A., in the Chair.

A paper on " Economic Research in Tropical Development, with special reference to British Guiana and British Malaya " was read by WALTER RANALD DUNLOP, late Professor of Economics, Imperial College of Tropical Agriculture.

The following took part in the meeting:—THE HON. W. ORMSBY-GORE, M.P., Under Secretary of State for the Colonies, COLONEL SIR CHARLES E. YATE, Bt., C.S.I., C.M.G., SIR WILFRED COLLET, K.C.M.G., Mr. H. HAMEL SMITH and DR. J. AUGUSTUS VOELCKER.

The paper and discussion will be published in a subsequent number of the *Journal.*

EIGHTH ORDINARY MEETING.

WEDNESDAY, 28TH JANUARY, 1925. SIR GEORGE HOPWOOD HUME, M.P., Alderman, London County Council, in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Baker, Reginald Percy, London.
Bolton, Herbert Cookson, London.

Hammond, Miss Winifred, London.
Leefe, B. W., London.
Logsdon, Stanley E., Pernambuco, Brazil.
Uddin, A., London.
Whittaker, William Thomas, London.

The following Candidates were duly elected Fellows of the Society:—

Bates, Walter, Richmond, Indiana, U.S.A.
Bond, Benjamin Davis, M.A., M.D., Kohala, Hawaii.
Burne-Jones, David, London.
Canning, Arthur Richard, London.
Dunne, Daniel Patrick, Clifton Junction, Manchester.
McMichael, Leslie, London.
Tejpal, Pandit N. L., Ludhiana, Punjab, India.

A paper on "The Electrical Equipment of the London County Hall" was read by MR. CHARLES A. BAKER, M.I.E.E., Assistant Engineer, London County Council.

The paper and discussion will be published in a subsequent number of the *Journal.*

CANTOR LECTURE.

On MONDAY EVENING, FEBRUARY 2ND, 1925, MR. V. E. PULLIN, Director, Radiological Research Department, Woolwich, delivered the third and final lecture of his course, "Radiological Research—A History."

On the motion of the Chairman, PROFESSOR E. N. DA C. ANDRADE, a vote of thanks was accorded to Mr. Pullin for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

SIR GEORGE BIRDWOOD MEMORIAL LECTURE.

FRIDAY, JANUARY 9TH, 1925.

THE HON. VICARY GIBBS in the Chair.

THE CHAIRMAN said that the pleasant task fell to him of introducing his distinguished friend, Sir David Prain, who was to deliver the Sir George Birdwood Memorial Lecture. He was well aware that there were very few present who needed an introduction to Sir David, who was going to give them an account of Government Botanical Gardens. He did not suppose that the lecturer would include in his lecture a very favourite garden of his own, a very small one, not much bigger than the Physic garden in Chelsea; but it was a garden of which he was very fond, because it was one he used to know when he was an undergraduate at Oxford. It was a charming pleasaunce and gave him his first interest in trees, which no doubt had a great influence on his life. Though a very undistinguished person he yet had something in common with Sir David Prain, because both of them had been always lovers of plant life, Sir David with the scientific knowledge of a botanist, and himself in the humble rôle of a gardener and collector. He was led to take an interest in gardens by seeing the beautiful trees in the little botanical garden at Oxford.

The lecture delivered was:—

GOVERNMENT BOTANIC GARDENS.

By Lieut.-Colonel Sir David Prain, C.M.G., C.I.E., LL.D., F.L.S., F.R.S.,

late Director, Royal Botanic Gardens, Kew.

An invitation to deliver a Sir George Birdwood Memorial Lecture comes as an especial honour to one who has been indebted to Sir George for help in connexion with economic enquiries in their historical aspect. Yet the acceptance of that invitation by one who has had occasion to investigate further questions already illuminated by Sir George's touch has involved responsibilities he would have found it more difficult to undertake, had not the Committee of the Indian Section of the Royal Society of Arts, with a kindness for which he has to thank them, prescribed the subject to be discussed.

Sir George's comments on Garcia show that the work of Botanic Gardens interested him, and suggest that he regarded it primarily from an historian's standpoint. Though it be impossible now to treat the theme with all Sir George's erudition, it is desirable to approach it in Sir George's spirit. To an audience like this Sir George might have illustrated from Indian experience the purposes Government Botanic Gardens fulfil, though he would have had to refer, in passing, to Botanic Gardens other than Indian. All botanic gardens depend for success in their undertakings on their capacity to enlist the sympathetic co-operation of cognate organisations. But when explaining what a botanic garden is, Sir George could hardly have confined his references to Indian examples. Notwithstanding the uniformity of purpose which enables botanic gardens to render each other effective service, these institutions cannot claim a corresponding uniformity of origin. The Government Botanic Gardens of Asia, in particular, owe their formation to motives rather different from the reasons that have led to the existence of most of the Botanic Gardens of Europe.

Many who take pleasure in visits to Botanic Gardens express their inability to discriminate between an establishment of this kind and a public park. Some who derive benefit from such visits seem to imagine that a botanic garden must subserve a horticultural purpose. Botanic gardens do occasionally possess amenities that render them places of popular resort; they often supply information that gardeners are glad to secure. Yet, however natural these somewhat discordant ideas may seem, they overlook the fact that a botanic garden exists to further botanical ends.

Botanical ends have been modified oftener than once since the Greek term

" botanicey " first came to indicate, in English letters, the science of " knowing plants," and was used in order to contrast the study of plant-characters with " phytology," which, even after the middle of the XVIIth century, still was " the art of ascertaining the temperatures, virtues and uses of plants, as tending to the curation or sustentation of the body." This particular definition was written at Oxford and was published in 1659. It is desirable to note the place and the date. A generation before this definition was formulated, the University of Oxford had been supplied with a chair for the teaching of " botanicey : " that University had to wait a decade after this definition was published ere it found a " professor of botanicey "—the first of the kind in England—to fill that chair.

Phytologists, intent on the study of plant-qualities, had been conscious, since the middle of the XVIth century, of the pressing need for a further knowledge of plant-characters. The doubling of the Cape and the discovery of the Western Hemisphere had resulted in an almost overwhelming influx of new material ; " phytologists " were no longer able to discriminate, by classical or mediæval criteria, between plants whose products were useful and others whose products were valueless or might be harmful.

This renaissance co-partnery between " botanicey " and " phytology " subsisted so long as the study of plant-structure and plant-function lay outside the domain of " natural history." Their alliance was so close that the science of " botanicey "—now " botany " for short—came to be looked upon as the basis of, rather than as an adjunct to, the "art of phytology." In 1663 those who in this country laid down the rules that should guide the conduct of seekers after scientific truth made it an axiom that the improvement of new natural knowledge for use should go hand in hand with its improvement for further discovery. By the middle of the XVIIIth century " botanists " had realised the importance of plant-function on the reproductive side. They believed that a solution of the " mystery of sex " might help them better to classify the vegetable kingdom and to elucidate the natural history of plants. They could now study plants philosophically : " plant-distribution " and " plant-association " received as much attention as " plant-characters " and " plant-qualities." This of necessity made the " botanist " also a " phytologist "—a modification wholly beneficial. Unfortunately, however, the " phytologist " of 1750, the year in which this wider philosophy of plant-study was first formulated, did not require to profess mastery of the science of " botany "; the application of the natural knowledge of plants, which was the " phytologist's " duty, was still considered an " art."

The earlier half of the XIXth century brought further changes. The study of " vegetable statics," hitherto a branch of " natural philosophy," was found to belong to biology as well as to physics ; anatomy demonstrated the existence, chemistry tried to explain the purpose of the " cell." Intensive study of the plant as a vital mechanism appeared to be possible without an extensive knowledge of plants as living organisms; by a process of reasoning familiar in other connexions, students of "plant-structure" and of "plant-function on the nutritive side" came to regard themselves as the people with whom wisdom must die. They arrogated to themselves the designation "botanist"; students of plant-characters and plant-qualities, of plant-distribution and plant-association were, at best, only "natural historians." A new century has seen further modifications. The study of plant-function on the nutritive side, whether under those normal conditions that we term physiological or those abnormal ones which we regard as pathological, has made it clear that growth depends on factors other than the nature of the substratum. Plant-association now possesses a biological significance so profound that students of oecology seem at times disposed to relegate "morphology" to the position that laboratory-research in the XIXth century deemed appropriate to cabinet-investigation. On the other hand, the study of the "mystery of sex," renewed in the XIXth century with a vigour induced by the mastery of experimental method, has been extended with success into realms undreamt of in the XVIIIth century. As a result the study of the characters and qualities of plants has acquired a new importance, both for those engaged in the botanic garden or the field in handling old and in raising new plants, and for those busy in the herbarium or the museum in supplying the systematic and synoptic data without which natural knowledge cannot be applied so fully as it should. The tendency, displayed in the XVIIIth century and insisted on in the XIXth, to regard the application of natural knowledge as a matter which concerns only the arts and crafts interested, has for the time being disappeared. Now, even more definitely than in 1750, botany is the branch of natural science whose business is the study of vegetation in all its aspects.

These changes in the scope of plant-study have affected workers in botanic gardens as greatly as they have affected those whose investigations are conducted in the field, the cabinet or the laboratory. In spite of this it sometimes appears, to those unfamiliar with what botanic gardens do, that there has been less modification in botanic garden methods than in laboratory- or cabinet-practice. Appearances are at times misleading; the misapprehension in this case is one of the consequences of incomplete observation. Workers in a botanic garden are subject to influences that hardly affect those privileged to labour in the field, the cabinet, or the laboratory. The field-botanist is free to confine his attention to the philosophy of plant-distribution or to that of plant-association, as he may decide. The cabinet-worker may devote his energies to the study of the characters, or the qualities, or both, of a single natural group of living organisms; the laboratory-student may concentrate his attention on the solution of definite morphological or physiological problems. But the garden-worker who deals with taxonomic problems has to use them as means to practical ends. The botanic garden-worker realises that the somewhat arrogant XIXth century distinction between

" scientific " and " systematic " botany is only a rather ungracious variant of the more refined XVIIIth century objection to " botany "—the science of " knowing plants"—as an occupation which may amuse the fancy and exercise the memory without improving the mind or adding to real knowledge. The botanic garden-worker is aware that when, in the field or the cabinet, "system " is treated as an end in itself, this objection may be valid. But the botanic garden-worker, being a " phytologist " as well as a " botanist," knows that without system it is not possible to carry out that part of his duty which involves the making of natural knowledge available to industry and commerce.

Towards the results of laboratory-research the attitude of the botanic garden resembles that maintained towards cabinet-study. When applying the physiological knowledge gained by the laboratory worker, whether in relation to health or disease, and whether on the nutritive or the reproductive side, the worker in a botanic garden remains interested in the morphological bearings of his investigation, and makes himself as conversant with the characters and qualities of the plants employed as if he were an herbarium–or a museum–student.

To this freedom to concentrate attention on particular problems or particular aspects of problems the success of work in the laboratory, the cabinet and the field is often due. But if the necessity to retain old as well as to adopt and apply new methods, which work in a botanic garden involves, may at times seem to possess certain extrinsic drawbacks, it has also some intrinsic advantages. It permits, among other things, a continuity of interest and effort that need not be limited to the lifetime of the individual worker, and need not disappear with the dominance of a particular phase of botanical thought.

One influence to which this continuity is to some extent due is that exercised on botany by gardencraft, whose aid is essential to the management of a botanic garden. It is this feature which explains the idea that a botanic garden exists to serve the purposes of horticulture. Yet it is this feature which enables us, on further thought, to realise that this idea, so often entertained, must be the converse of reality. There is, no doubt, in any botanic garden an intimate alliance between botany and gardencraft. But a botanic garden is not, on that account, an institution in which botany professes to demonstrate how plants should be grown; it is a place where gardencraft assists botany to increase natural knowledge.

The tendency to confuse a botanic garden with a public park is more intimately connected with our modern and popular conception of a " garden." We are apt to forget that this term, shorn of accidental associations, means no more than an enclosure which shelters cultivated plants. We are tempted to think of a " garden " as did that great Lord Chancellor who remarked with truth, three hundred years ago, that " to garden finely " was a perfection " reserved for ages grown to civility and elegancie." The " garden " Bacon had in mind is an enclosure which, while affording protection to the plants contained, promises its owner and his friends intellectual pleasure and artistic satisfaction. So remote is this conception from the original one, yet so widely does it prevail, that when national needs, begotten of war conditions, called for a reversion to primitive practice, a new name had to be found for an old thing. The " allotment," which reiterates the uncivil and inelegant precept that man must eat his bread in the sweat of his face, reminds us that the original purpose of the " garden-close " was severely economic; that it was meant to provide for man's bodily welfare, without making any offer of mental refreshment or any appeal to æsthetic feeling. Those familiar with tropical conditions recognise in the " allotment " a return, dictated by necessity, to that undifferentiated husbandry characteristic of hot countries with a maritime or a monsoon climate, where the plough has not yet supplanted the hoe.

In one respect the " allotment," though possibly more perfect, is perhaps less complete than the tilled enclosure in which no distinction can be drawn between the " field " and the " yard." The primitive enclosure served a double purpose: it ministered to the sound by providing much of what the husbandman could eat and some portion of what he might wear; it tried to serve the sick by supplying what, it was thought, could mitigate pain and what, it was hoped, might cure disease. The disappearance of domestic remedies from modern enclosures is not, however, a direct result of the prehistoric specialisation which led to the evolution of the " medicine-man," who found his prestige enhanced when he could supplement and in time replace the familiar " simples " of his tribe by drugs collected afield and in secret, under favourable planetary conjunctions and during suitable phases of the moon. Our neglect of these plants is perhaps more immediately traceable to that modification of outlook which led many of the northern races of Europe to regard with some suspicion matters in any way connected with the Church of Rome.

The Latins, whose interests were largely economic and whose curiosity did not always extend beyond the practical, classified the plants they cultivated or put to economic use in accordance with their qualities. This grouping was accepted by renaissance students, and, among the groups thus recognised, those that chiefly concern us now were the " esculent," the " medicinal," the " coronary," the " aromatic." The group of " medicinal plants " included the sources of mediæval domestic remedies—plants rarely grown in modern northern gardens. They were, perhaps, hardly more familiar in classical gardens than in ours. Though medicinal plants are discussed by authors like Dioscorides and Pliny, the exploitation of the drugs they yielded was largely left, in classical days, to specialists who were often accused of witchcraft and sometimes suspected of murder. In this connexion the advent of a Levantine faith, whose influence grew as that of classical " civility and elegancie " decayed, did rather more than banish dark beliefs which cultured paganism was content to entertain. If the laity in the middle ages showed a disposition to abide by this pagan habit, the early Church set its face against it and reverted to the practice of growing homely remedies. The original undifferentiated "tilled enclosure" had harboured, along with the rudiments of horticulture and of agriculture, also the germ of medicine, and thereby inspired the formation of the "herbularies" that, in the oldest of monastic establishments, found a place alongside the plots in which the brethren grew their legumes and their fruits. By a simple and easy transition the monastic "herbulary" developed into the "physic garden" characteristic of the medical schools attached to the Universities that sprang up so freely after the fall of Byzantium and the consequent revival of learning in Western Europe.

It is sometimes believed that because, by an equally easy transition, such a "physic garden" could develop into a botanic garden, there may be some essential connexion between "medicine" and "botany." While it is true that some five botanic gardens in Europe out of six began as "physic gardens," the connexion between "botany" and "medicine" was really accidental. The cultivation of "esculent plants" was attended to as carefully in monastic gardens as was that of "medicinal plants." If the cultivation of "herbs of healing" were due to a conscious ecclesiastical effort to place the use of drugs on a higher plane than in pagan days, the cultivation of food-plants was an equally conscious endeavour to preserve something worth saving from the wreck of the Western Empire. In the "physic gardens" to which these monastic "herbularies" gave rise, there was the same combined practical cultivation and phytological study of vegetables and drugs; the same equal attention to the maintenance of health and the treatment of disease. The urgency of the need for botanical aid, in which renaissance "phytology" stood, was less in connexion with new drugs than in connexion with new foods and food-accessories, like the potato, the topinambour, cocoa, tea, tobacco and so many more, then for the first time finding their way to Europe.

This alliance of the mediæval art of "phytology" with the renaissance science of "botanicey" was really a reversion to an attitude manifested in Greece some eighteen centuries earlier. The garden formed by Aristotle, in which his pupil Theophrastus discoursed περὶ φυτῶν, was nearer in purpose to a modern botanic garden than any "physic garden" of the XVIth century. This explains Rousseau's remark that Theophrastus was the only "botanist" the ancient world produced: Theophrastus, alone among classical writers, dealt with plants as living things rather than as sources of useful products. What we learn of his doctrine shows that he was inspired by "scientific curiosity." His teaching was as philosophical in spirit as the teaching of botany is to-day. If, since the middle of the XVIIth century the "botanist" has been also a "phytologist," we have to admit that in the days of peripatetic philosophy the "phytologist" tried to be what the "botanist" of the XXth century is.

Some of the plants used by Theophrastus to illustrate botanical facts show that his garden contained "coronary" as well as "esculent" and "medicinal" plants. This does not imply, however, that his enclosure was a "garden" in the renaissance sense. The Greeks and Latins could garden well; they had mastered the art of making domesticated plants thrive. They grew in their enclosures many "coronary" plants for their intrinsic beauty or for their scent. But the intellectual pleasure these "herbs of grace" afforded was tempered by their suitability for the making of wreaths. The classical householder did not "garden finely;" he made no conscious effort to dispose the "coronary" plants he cultivated so as to produce a pleasing general effect. Nor did mediæval monastic enclosures do more in this direction. A faith that strove to wean the thoughts of believers from this imperfect world paid but little attention to what the unconverted considered "herbs of grace." It did, indeed, condone the cultivation of some "coronary plants," less because of their "grace" than owing to their association with legends concerning Our Lady and with traditions as to the lives and deaths of saints and martyrs. The impulse that, in renaissance days, led men and women of means and taste "to garden finely" was not identical with the incentive to form "physic gardens." The formation of enclosures to afford intellectual pleasure and satisfy artistic desires was an amplification of the classical regard for "coronary" plants rather than a development of monastic practice. That amplification was due to the use of classical "herbs of grace and faith" in attempts to reproduce those Oriental "paradises" whose existence was attested in works that were canonical and whose nature could be gleaned from accounts of Arab culture.

When the makers of renaissance "pleasaunces" happened to be imbued with "scientific curiosity" as well as with "artistic skill," such establishments became at once as truly botanic gardens as any of those that had originally been "physic gardens." The renown, in their day, of gardens like that of John Brancion in Flanders, that of Cardinal Farnese at Rome, that which the Burgomaster of Terneuzen put at the disposal of Pastor Peter Hondius, that of John Goodyer in Hampshire—to mention but a few private establishments which chanced to be almost contemporary—was at least equal to that of the gardens attached to Universities like those of Padua, Pisa or Leiden; those of Paris, Montpellier or Oxford. Though the "physic gardens" attached to Universities have so often continued to exist as Botanic Gardens, while the private "pleasaunces" that were botanic gardens from the time they were formed rarely managed to survive, the difference in their fates was due to the character of their ownership rather than to the nature of their origin. Two instances from English botanical history may suffice to explain the situation. The private garden of John Gerard, herbalist of Holborn, one of the best known "physic gardens" in this country at the close of the XVIth century, ceased to exist after its owner's death. On the other hand, an XVIIIth century English " pleasure garden," which owed its origin to the artistic instinct, and its conversion into a botanic garden to the scientific curiosity of an enlightened Princess, enjoys still a renown wider than that of any other botanic garden in the Empire, and is regarded by strangers as second to no botanic garden in the world.

The absence of allusions to other classical gardens in which plants were grown to gratify the " scientific curiosity " of those who visited them, suggests that the idea underlying the formation of the one in which Theophrastus lectured may have been peculiar to Aristotle. Egypt had at least one garden which combined to some extent the features of a " physic garden " and a " pleasaunce." Babylon, it appears, had its " paradise." The medical writings of India and Assyria hint that they may have had " physic gardens." But it is difficult to find an exotic source for Aristotle's inspiration, and we are only prevented from feeling assured that it originated with him because the same conception happened to take concrete form in the Western Hemisphere. When Europeans reached America, Mexico could boast the possession of two botanic gardens, designed to satisfy both the economic and the scientific curiosity of Montezuma's subjects. Spain, after her conquest of that kingdom, did what she could to maintain and preserve one of these gardens.

The idea which had guided Aristotle and inspired the rulers of Mexico occurred once more to those English planters in the West Indies who, in 1764, established in the grounds of Government House at St. Vincent a garden stocked with useful and ornamental plants, to illustrate what the West Indian colonies could produce, and to demonstrate what plants of exotic origin might be grown in the West Indies with advantage to the inhabitants. Those who founded this garden were, apparently, actuated by more than an economic purpose; the designation they gave it indicates that they hoped the new garden might also satisfy scientific curiosity. Their action was but a further instance of that sympathy with the improvement of natural knowledge manifested by West Indian planters when they gave the financial assistance which ensured the publication of scientific treatises dealing with the natural history of Jamaica, Barbados, the Bahamas and Carolina. The well-known works of Sloane, Hughes, Browne and Catesby were prepared in emulation of the more famous ones dealing with the natural history of Malabar and the Moluccas, prepared by servants of the Dutch East India Company. The appearance of these latter works by Rheede and Rumphius had not conveyed to English merchants in the East Indies the lesson they taught English planters in the West Indies. The " scientific curiosity " of the English East India Company in the natural products of its territories, if it existed at all, was more than satisfied by what its Netherlands rival had done. But when English planters in the West Indies went a step further than Dutch merchants in the East Indies had gone, they supplied the two competing Eastern corporations with food for thought. The Dutch East India Company, whose example as regards natural history surveys had been imitated in the West Indies, did not pay the latter the compliment of copying at once the West Indian idea of establishing a botanic garden. The English East India Company, which had not thought it necessary to make a survey of the resources of its possessions, followed the example set by the West Indies so far as the establishment of experimental gardens was concerned.

The history of the two great East India Companies affords a clue to these diversities of purpose. The rivalry which marked their careers was the outcome of a community of interest in the products of what were known to classical and renaissance naturalists as " aromatic plants." These plants were often linked with " coronary " ones, much as " esculent plants " were associated with " medicinal " ones. Yet they were less frequently grown in classical gardens than their " coronary " companions; those best known were common on the hillsides of Greece and Italy, those whose products were most in demand rarely found the climate of the northern Mediterranean seaboard congenial. Supplies of these products reached the ancient world, largely by way of the Red Sea, from the Emporium Aromatum on the East Coast of Africa, or from Western India and the lands beyond that lay "under the wind." Sellers of the " incense " of Zingis and the " spices " of the two Indias were less reticent regarding these commodities than were those who retailed drugs and the " drowsy syrups of the East." But the confusion as to their characters, manifest in classical allusions to " aromatic plants," is as bewildering as the dubiety regarding the qualities of many of the familiar " medicinal " ones. If those who sold " balsams " and " spices " were more communicative, they were even less well informed than dealers in " simples." Perhaps the Oriental middlemen from whom classical merchants derived their supplies did not always tell the same tale or provide articles true to name.

The fall of the Western Empire caused less dislocation of the traffic in Eastern products than it did to most of the activities of the Latin world. If the barbarians who overthrew Rome preferred European foods, they soon developed a taste for Oriental condiments; the trade in " spices," which flourished during the middle ages, became a Venetian monopoly. It was a wish to break this monopoly that took the Portuguese round the Cape of Good Hope and led them to deprive Arab seamen of the maritime supremacy they had so long enjoyed in the seas beyond the Cape of Currents. It was a resolve to destroy the new monopoly that induced the Dutch to follow the Portuguese and deprive them of their mastery of the Indian Ocean. It was a determination to share in the profits of the spice trade that led the Merchant Adventurers of London to form an East India Company of their own. As regards most Indian products the two corporations could buy and sell on fairly equal terms. But as regards the traffic in " cinnamon, nutmegs and cloves," equally coveted by both companies, the Dutch were at an advantage: they had reached the

Indies first and had taken over from Portugal the political as well as the commercial supremacy of Ceylon and the Spice Islands. The example set by the West Indies in forming a Botanic Garden at St. Vincent gave the English East India Company a hint which the Dutch East India Company hardly required. The English Company resolved to form a garden in which to naturalise, if possible, the " aromatic plants " characteristic of, and confined to, islands held by the Dutch.

The lead in this enterprise was taken by the oldest of the English presidencies. The Government of Fort St. George established an experimental garden at Samalcotta as a centre in which to grow and from which to distribute the plants that yield " cinnamon, nutmegs and cloves," and another similar garden at Marmalon, to be used, like the garden at St. Vincent which had supplied the idea, for the naturalisation and distribution of economic plants generally. The Dutch in Ceylon, with this example at their door, now formed a garden on the lines of that at Marmalon, in Slave Island, near Colombo. But the effect of the action taken by the Government of Madras that was to be of most consequence to Eastern Asia was that produced on the Government at Fort William in Bengal: the healthy rivalry between the two presidencies could not suffer the one at which the Governor-General resided to lag behind its neighbour to the south. The Bengal Government gave favourable consideration to a proposal by the Secretary to their Military Board that a botanic garden be formed at Calcutta. This proposal was approved by the Court of Directors; the new garden was founded in 1786. From the outset, the Calcutta garden was intended to combine the objects for which the two Madras gardens had been formed. There was a hope that the effort to establish " cinnamon, nutmegs, and cloves," which had failed in Coromandel, might succeed in Bengal; there was a further hope that it might be possible to naturalise in Bengal teak and other trees, from various parts of India and Burma, whose timbers were of importance to shipbuilders, in order that the company might eventually be able to construct new and repair old vessels with material grown in the vicinity of its own dockyard on the Hughli.

The records of the two Madras gardens show that they differed in more than their original purpose. That at Samalcotta was placed in charge of Dr. William Roxburgh, whose competence as a " phytologist " is established beyond dispute by the recognition accorded his economic labours by the Royal Society of Arts, and whose eminence as a " botanist " was manifested in his great work on the " Plants of Coromandel," prepared while he was superintendent of the Samalcotta garden. The advantage to his charge and to his correspondents of a superintendent who " knew plants " and could describe and name them was that anything raised at and distributed from Samalcotta must be exactly determined and accurately designated. The garden at Marmalon was in charge of a competent " phytologist " who, however, was not a " botanist " in the contemporary sense and as defined by the great Linnaeus.

We read in an official letter to the Governor of St. Helena, dated February 15th, 1791: "I have forwarded some trees under their Indian names rather than wait for the examination of their flowers and fructification." The Dutch garden in Ceylon seems in this to have resembled the garden at Marmalon. So, during its earlier years, did the Calcutta botanic garden. But when, in 1793, Lieut.-Col. Robert Kyd, its founder and first superintendent, died, the Court of Directors at home appointed Roxburgh to succeed him, and ordered his transfer from the Madras establishment to that of Bengal. With the advent of Roxburgh the Calcutta garden became a botanic garden in fact as well as in name. But this change in the character of the Calcutta garden made it responsible, at least indirectly, for the disappearance of the two Coromandel gardens: that at Samalcotta was given up when Roxburgh left; that at Marmalon was abandoned some years later. When Ceylon was seized by the English, the garden established by the Dutch was abolished. But the Calcutta garden was soon to be directly responsible for the formation of two new gardens, to the east of the Sea of Bengal, modelled on the one which had been made by Roxburgh for the Madras Government at Samalcotta.

When the English took possession of Ceylon they also occupied the Moluccas. The Company, notwithstanding Roxburgh's experience at Samalcotta and Kyd's experience at Calcutta, resolved to repeat, on a more extended scale, their efforts to naturalise "cinnamon, nutmegs and cloves" in India. We gain a more vivid conception of this great experiment from the correspondence of Dr. Francis Buchanan, Roxburgh's friend and successor, than from contemporary official records. Writing from beyond the Megna on May 10th, 1797, Buchanan said to Roxburgh: "I congratulate you on your success from the Spice Islands, though I am much afraid that you will have great difficulty in reconciling the nutmeg plant to the climate of Bengal. Do not you think that it might be advisable for the Company to form a plantation of nutmegs, cloves and cinnamon near Cape Comorin? For it must be obvious that our retaining possession of the Spice Islands and Ceylon at the peace will be extremely precarious."

Buchanan's fear was justified and the Government of Fort William, when it decided to seek a locality less unfavourable than Lower Bengal, chose Buchanan as the officer to look for it. But the Bengal Government did not send Buchanan to Cape Comorin; the locality they desired must be one within the Bengal presidency. Writing on January 1st, 1799, to his old friend and fellow-student, the President of the Linnean Society, Buchanan said: "Last March, April and May I was employed by the Board of Trade in examining the provinces of Chittagong and Tippera to find out the places most likely to answer for the cultivation of spices." Soon after this deputation had been arranged, but before it had begun, Roxburgh was invalided to the Cape. When the deputation ended, Buchanan was directed to act as superintendent of the Calcutta Botanic Garden until Roxburgh should return. Buchanan's letter to Dr.

J. E. Smith, therefore, goes on : " My report was unfavourable ; but Chittagong is going to be tried, and I shall soon send off a number of nutmeg and cinnamon trees to be distributed among the proprietors of the southern part of the Chittagong province, especially in the island of Mascally."

By the time that Roxburgh returned, restored to health, in October, 1799, the Board of Trade knew that Buchanan's judgment as regards Chittagong had been as accurate as it had proved in respect of Bengal. The Bengal Government did not favour Buchanan's suggestion as to Cape Comorin ; this would have involved the transfer of their experiment to the Presidency of Madras. But Bengal approved an alternative suggestion, made by Roxburgh, for the formation of a botanic garden at Penang. This was acted upon in 1800, as was a further suggestion by Roxburgh, carried out in 1803, that a spice plantation be established at Fort Marlborough in Sumatra. The plants with which the latter was stocked were brought direct from the Moluccas by William Roxburgh, junior, who had been appointed by the Court of Directors in 1800 to the post of Assistant to his father in the Calcutta Botanic Garden.

The enthusiasm of the Government at Calcutta presently waned. The Penang Garden was able to ripen nutmegs ; the Fort Marlborough plantation proved self-supporting. But they were not under the eye of the Governor-General, and when, in 1805, Roxburgh took furlough to Europe and Buchanan went to England on duty as a member of Lord Wellesley's staff, the opportunity was taken to abolish the Penang Garden, though the plantation in Sumatra, which was free from the objection of being a " scientific " establishment, was permitted to thrive. The Calcutta Botanic Garden, of which young Roxburgh held charge during his father's absence, could not be suppressed without the sanction of the Court of Directors at home.

It was, naturally, Roxburgh's hope that his son might be nominated his successor, and the Court of Directors went so far as to agree, provided young Roxburgh should be found qualified. The reason for the appointment of Roxburgh himself in 1793 was that the Court had been advised that part of the duty of the superintendent of the Calcutta Botanic Garden should be to describe the vegetable productions of their Indian possessions and to communicate these descriptions to the learned of Europe. They could hardly accept Roxburgh's plea, submitted in 1806, that for the post he occupied " science is not necessary ; that a cultivator alone is required : " to have done so would have been to stultify the earlier decision. Young Roxburgh, by his father's own admission, however competent he may have been as a " phytologist," was not a " botanist " able to describe plants and communicate their descriptions to the learned of Europe. But if Roxburgh's wish could not be gratified, his son's prospects were not injured. Soon after Roxburgh's return, the superintendentship of the spice plantation in Sumatra became vacant, and in 1807 young Roxburgh was placed in charge of the garden which had been stocked by himself in 1803. This post, which he was well qualified to fill, young Roxburgh held until he relinquished the Company's service in order to become a private planter in Sumatra, a decision he reached before his father retired.

After a period of quiescence came the wave of scientific enthusiasm, which saw the formation of a botanic garden in Java in 1817, the conversion of a " pleasure garden " at Saharanpur, which owed its existence to the munificence of an Indian noble of means and taste, into a botanic garden for Northern India, and the transfer in 1821 to a more suitable locality of the garden in Ceylon which had been revived in 1810. In 1822 Dr. Nathaniel Wallich, Buchanan's successor at Calcutta, visited the Malay Peninsula as the guest of Sir Stamford Raffles, and was able to secure the restoration of the Penang Botanic Garden. In 1823 Raffles formed a new botanic garden at Singapore. Again, however, official enthusiasm was short-lived; the second Penang garden was abolished in 1826; the garden formed by Raffles at Singapore was abandoned in 1829. After another and longer period of neglect came another wave of enthusiasm; a second botanic garden was formed at Singapore in 1878 and a third botanic garden at Penang in 1884. The latter only survived until 1910, and if the lessons of history justify an " intelligent anticipation of events," we need hardly doubt that one day some reason may be manufactured for the abolition of the garden which at present replaces the one whose formation was due to the foresight and judgment of Sir Stamford Raffles. The experience of India proper has hardly differed from that of Malaya. Efforts made by the Presidency with which Sir George Birdwood was most intimately associated were not more successful than those of Madras: largely owing to him, Bombay can boast an Oriental " paradise," but hardly a botanic garden. Even in Upper India, for which the Saharanpur Garden served as an useful scientific centre during three-quarters of a century, the attempt to maintain a Botanic Garden has been abandoned. There is now only one Indian Government Botanic Garden.

This record is perhaps disappointing, but it need hardly be regarded as surprising. A botanic garden, to be of use, involves considerable recurrent expenditure. If its work is to be of value, the Government that maintains it must discourage attempts to produce direct revenue: energy expended in this direction involves corresponding impairment of scientific efficiency. If a province cannot afford a botanic garden which brings no revenue, it is sounder economy to do without one: the return which a botanic garden brings is indirect. How vast that return may be South-eastern Asia knows. By what they have done in connexion with the creation of such industries as those connected with tea, cinchona and rubber, all the outlay by their respective Governments in respect of the botanic gardens of Calcutta, Buitenzorg, Peradeniya and Singapore has been repaid an hundredfold.

If the facts suggest that there has been a tendency at times to abolish a botanic garden whenever this was possible, this policy has rarely been the immediate result of official antagonism towards institutions that are included in the group quaintly classed, by secretaries for finance, as " Scientific and other Minor Departments." More often the action has been an indirect consequence of the attitude towards the work of a botanic garden adopted at various times by botanical thought as a whole. That attitude has not always been the same; that it should often have been a critical one need hardly create astonishment. It has been, and must remain the duty of a botanic garden to increase the sum of natural knowledge; to place the natural knowledge it may possess at the disposal of industry and commerce; to do what it can to apply this natural knowledge in in practice. Among the steps taken by the Calcutta Botanic Garden, for example, to add to natural knowledge may be mentioned those of systematic and economic survey, both commenced during the incumbency of Roxburgh, and the former, at least, prosecuted with vigour ever since. Systematic survey work began in the Spice Islands in 1796; economic survey work began when Roxburgh's suggestion that Buchanan be sent on deputation to Chittagong was carried into effect in 1798. In survey work reliance must be placed on the method of observation. The obligation of botanic gardens to depend on this method in some of their work has been the subject of unfavourable criticism by those so fortunately situated as to be able to employ the method of experiment in all they undertake. In placing the natural knowledge they possess at the disposal of others, it is the duty of botanic gardens to arrange for floristic and monographic study, a proceeding which ensures for them the disapproval of those who regard " system " as unscientific and the preparation of hand-lists and gazetteers as mechanical. More antiquated even than the continued reliance on observation and the continued employment of system, seemed to the academic eye of half a century ago, that continued belief of botanic gardens in the validity of the XVIIth century injunction that the application of natural knowledge is as deserving of attention as its advancement. To this determination of botanic gardens to abide by what was good in the old, while absorbing what was best in the new, India owes her tea-gardens, Java her cinchona plantations, Ceylon and the Malay Peninsula their rubber industry. But the English and the Dutch Indies owe to this attitude on the part of their botanic gardens another and perhaps a greater debt. What has been gained as the result of these successful ventures can be computed. What has been saved to industry and commerce by the avoidance of enterprises that botanic gardens could show were doomed to failure, is almost incalculable.

It is fair to remark that one of the " scientific " objections to botanic gardens is that for work of this kind such institutions are needlessly expensive instruments; that equally good results may be anticipated if the work of exchange and cultural experiment be entrusted to cultivators who are not botanists. Natural affection, we have seen, induced a " botanist " so renowned as Roxburgh to express this very view. The technical portion of the task no doubt can be so provided for. But, if exchanges of plants are to be of permanent value, there must be an assurance that the plants transmitted are precisely identified. This can only be obtained when the plants imported by a distributing centre where there is no " botanist," have come from a botanic garden; or where those despatched from such a centre are received by a botanic garden. It is also fair to admit that in certain European scientific circles it has at times been urged that the day of botanic garden exchanges of useful plants is over, and that now the work of the plant-breeder should replace that of the field-observer. But this is not claimed by the student of genetics, whose work is nowhere more highly valued than in a botanic garden. Nor is it claimed by those interested in plant-breeding and plant-importation in America, where the affection for XIXth century habits of thought, still characteristic of Europe, has died out.

The records of the garden founded by the Government of Madras at Marmalon illustrate the conditions under which the " phytologist " who is not a " botanist" has to work. In 1786, the year in which the Calcutta Botanic Garden was founded, Dr. James Anderson happened to observe on a " Nopal " plant some cochineal insects. He did not know, and we may never learn, whether the insect he noticed was that which supplied the *grana silvestris* of commerce; it was clear to him that it was not the true cochineal which supplied the *grana fina* then in demand in the trade. Nor did Anderson know whether the " Nopal " on which he observed the insect was a plant on which the true cochineal could be raised. Anderson reported his observation to his Government, and through them recommended that steps be taken by the Court of Directors to introduce the true insect to India. The Court sought the help of the War Office and the President of the Royal Society: plants of the *Cactus cocci*, as the *Opuntia* required was then termed, were transmitted to Madras from Kew. Writing on February 19th, 1790, to the Governor of St. Helena, Anderson said: " Having recommended that the Honourable Court of Directors shall first introduce the genuine cochineal at St. Helena, from whence it may easily and certainly be forwarded here, I send you another box of Nopals by this opportunity of the ship Pigot." Again, on September 15th, 1790, Anderson wrote to the Governor: " Understanding that Sir George Yonge, Secretary of War, is establishing cochineal insects at Antigua with a view to transporting them to this country, in consequence of my publications on that subject, I have forwarded a dozen more Nopal plants that you may have abundance in readiness for their reception." A letter of September 14th, 1790, asking Government for authority to place these plants " on board the Houghton under the care of Capt. Munro," tells us that the plants were " twelve Kew Nopals." In that letter Anderson adds: " You may acquaint the Honourable the Directors, from my own inspection of the garden there [Marmalon], that it contains fifteen hundred very thriving plants of the Kew Nopal, many of them in flower, which might, if necessary, be immediately multiplied into as many thousands." The plants reached St. Helena safely; another letter to the Governor of St. Helena, dated February 15th, 1791, says: "I am favoured by this Government with your acknowledgment of the receipt of Nopal plants, which I have forwarded on different ships, and am happy to learn they are in so thriving a condition to supply an article of vegetable food for the inhabitants of St. Helena, for Covent Garden is not better supplied with asparagus than the markets of the kingdom of Mexico are supplied with the tender tops of Nopals which are every day brought to table."

One consequence of Anderson's publications regarding cochineal was that Bengal became as interested in this adventure as Madras. The first volume of the Calcutta Gazetteer, attractive to-day mainly for its newsletters from the seat of war in Mysore, and for its local advertisements, contains among the latter an intimation that a "Nepaulry" was for sale. It did not find a ready purchaser, for the notice had to be repeated with an assurance that the plants were ready to receive the insect. The speaker, in his early days in India, did not know what a "Nepaulry" was, and, so completely had the term disappeared, could obtain no information from more experienced friends. He wrote therefore to Sir George Birdwood, and, needless to say, had his difficulty cleared up by the return mail.

At what date the insect reached Madras from St. Helena, the records do not say. Anderson, was grateful for the sympathetic help given him, but was then preoccupied with other duties, for he added, in writing to the Governor of St. Helena, who was also President of the Planters' Society there: "The importance of the war here prevents my writing to my Government, who have duties of a very different nature to expect from me at present, but you may acquaint the Society that next year . . . . . . .it is my firm intention to shower the most choice productions of Asia upon their island."

Thus, on February 15th, 1791, did Dr. James Anderson express the spirit that always has guided and, doubtless, always will inspire, those whose privilege it is to be connected with an Indian Government Botanic Garden.

DISCUSSION.

THE CHAIRMAN (the Hon. Vicary Gibbs) said he was sure he would be expressing the views of those present when he moved a hearty vote of thanks to the lecturer for the very interesting lecture he had given. There was nothing that impressed him more strongly than the way in which the lecturer had brought out the immense value to commerce that botanic gardens had been, during the lifetime of many who were present that afternoon.

SIR EDWARD A. GAIT, K.C.S.I., C.I.E. (Chairman of the Indian Section Committee), in seconding the motion, said that though it was more than 20 years since Sir David left India to take charge of the Royal Botanic Gardens at Kew, the splendid work done by him in Calcutta was still well remembered by those resident there. He (Sir E. Gait) was not a botanist and was unable to speak of Sir David Prain's great professional qualifications, but, like many other old residents in Calcutta, he felt very grateful to Sir David and his predecessors for the great enjoyment which he had had at different times when, escaping from irksome official work, he had wandered about the well-kept gardens in Calcutta, and admired the beautiful flowers, Eastern and Western, and the ornamental trees, plants and ferns which were there in profusion. The lecturer had complained that in the popular mind there was a tendency to confuse botanic gardens with public parks, but he thought Sir David and superintendents like him were very much to blame for that. While there was a great deal in botanic gardens which nobody but a botanist could appreciate, there was so very much to admire in the masses of flowers and general decorative effect that the uninitiated were apt to forget that these things were mere accessories, and that the real object of the gardens was of a much more utilitarian character. It had come as a shock to him to hear that while Aristotle had formed what might fairly be called a botanic garden well over two thousand years ago, and while Montezuma could boast of two in Mexico at the time of the Spanish Conquest, botanic gardens founded by Europeans in modern times dated only from the 18th century. In recent times that deficiency had been made up, and there were now many botanic gardens which satisfied every scientific requirement. He thought that the lecturer might have dwelt, perhaps, a little more fully on the practical advantages—which were many—which had been derived from botanic gardens. Perhaps the reason for that was that the lecturer felt he had given as much as the audience could digest on one occasion, but he hoped that on a future occasion he would deal with that branch of the subject.

The resolution was carried unanimously.

Sir David Prain acknowledged the vote of thanks.

Professor H. E. Armstrong, F.R.S., in proposing a vote of thanks to the Chairman, said that Mr. Vicary Gibbs was well known to a large circle, particularly to those who visited the Horticultural Society. He had done a good work that day, but he (Professor Armstrong) was going to ask him to go a little further. The Royal Society of Arts had been fortunate in capturing Sir David Prain to deliver the lecture. Unfortunately many people passed away without leaving behind them any account of the vast amount of knowledge that they could have given to the world; they did not take the trouble to put what they knew on record. He did not know any one who had a greater fund of important and interesting knowledge at his disposal than Sir David Prain, and he should like to ask the Chairman to increase the debt owing to him by the Society by securing the appointment of a small Committee, together with a grant from the Board of Industrial Research, to chain up Sir David Prain, perhaps with a stenographer, until he had delivered himself of the things that he knew. It was with that rider he asked the meeting to give its thanks to the Chairman of the evening.

The motion was carried unanimously.

The Chairman said it had been a great pleasure to him to take the Chair and give any small support he could to Sir David Prain, to whom he owed so much. He thanked the proposer of the resolution for the kind words he had used, but Prof. Armstrong had much overrated his (Mr. Gibbs's) powers if he thought he was able to shut Sir David Prain up until he had delivered to the world all he knew, because that would be sentencing his old friend to penal servitude for life.

OBITUARY.

Charles Henry Wordingham, C.B.E., M.Inst.C.E., M.I.Mech.E.—Mr. C. H. Wordingham died at his residence at Redhill on January 28th. Born in 1866, he was educated at King's College School and King's College, London. On completing his articles as a civil engineer with Dr. John Hopkinson, F.R.S., he joined the staff of the United Telephone Company. From 1889 to 1892 he was third engineer of the Grosvenor Gallery generating station of the London Electric Supply Corporation. In 1892 he returned to Dr. Hopkinson and acted as his assistant in erecting the Whitehaven and Manchester generation stations. From 1894 to 1901 he was City Electrical Engineer to the Corporation of Manchester. In 1903 he was appointed Director of Electrical Engineering to the Admiralty, and was responsible for the entire electrical equipment of all H.M. ships, and for advising on electric light and power questions in H.M. dockyards and shore establishments. This post he held until 1918, when he retired from the public service and was created a C.B.E. He then resumed practice as a consulting engineer, and was engaged in advising on large power electric supply schemes for London and the Midlands.

Mr. Wordingham was a Past President of the Institution of Electrical Engineers, the Incorporated Municipal Electrical Association, the Junior Institution of Engineers, and the Illuminating Engineering Society. He was also President and Past Chairman of the British Electrical and Allied Industries Research Association, and one of the founders of the Electrical Development Association and of the Society of Radiographers. His publications included a work on Central Electrical Stations and numerous contributions to technical journals. He was elected a Fellow of the Royal Society of Arts in 1918.

Colonel Malcolm Hart Crump.—Information has been received of the death of Colonel Malcolm H. Crump, which took place on January 13th, at Bowling Green, Kentucky, U.S.A., at the age of 75.

Colonel Crump was born in Culpepper County, Virginia, in 1849. He graduated at the Virginia Military Institute at Lexington, and in 1877 he accepted the chair of Science in Ogden College. While thus engaged he became interested in the scientific development of southern Kentucky. An engineer and geologist of considerable note, he was among the first to realise the value of the rock asphalt deposits in Kentucky. At one time he owned 3,000 acres in Edmondson county, now the property of the Kentucky Rock Asphalt Company, and he took a deep interest in the construction of asphalt roads. Formerly he commanded the Third Kentucky Regiment, and during the Spanish-American war he served on the staff of Colonel Castleman, with the rank of Lieut.-Colonel.

He had been a Fellow of the Royal Society of Arts since 1911.

GENERAL NOTES.

St. Paul's Cathedral.—In connexion with the recent celebration of the bicentenary of Sir Christopher Wren, the Royal Institute of British Architects published a book on Wren and his work (including St. Paul's Cathedral) written by contributors each intimately acquainted with the aspect with which he dealt. As the profits of the sale are devoted to the St. Paul's Preservation Fund, it is suggested that many might consider that a pleasant way to help the fund would be to obtain this attractive and well-illustrated record, of which the title is "Sir Christopher Wren Memorial Volume: 1723-1923." The sale of only one thousand copies of the five guineas edition would enable the R.I.B.A., to hand over a sum of 2,000 guineas, to be acknowledged in the *Times* list in the name of each purchaser as a subscriber of two guineas. The price is £5 5s. and orders, enclosing remittance, should be sent to The Librarian, R.I.B.A., 9, Conduit Street, London, W.1.

SULPHUR DEPOSITS IN JAVA.—The Government of the Netherlands East Indies is making some effort to have the sulphur deposits of Java utilised, and recently called for tenders for the working of the Kawah Poetih deposits. From a report published in the official "Commerce Reports," it appears that sulphur is obtained in various parts of Java, but, up to the present time, very little has been done toward working these deposits, owing to the difficulties that will have to be overcome to make it a profitable venture. Borings of the Kawah Poetih deposits were made in 1919 by order of the Netherlands Indian Government Mining Service, and it is reported that the quantity of sulphur-bearing deposits amounts to approximately 1,000,000 tons, one-half of which is 60 per cent. pure sulphur, with an equal quantity of 20 per cent. purity, or a total of 400,000 tons of pure sulphur. There are several other sulphur areas in Java, some of which are being worked at the present time.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, FEBRUARY 9..Geographical Society, 135, New Bond Street, W. 8.30 p.m. Mr. J. M. de Navarro, "Ancient Trade Routes in Europe."

Victoria Institute, Central Hall, Westminster, S.W. 4.30 p.m. Prof. A. T. Clay, "The Amaru."

Surveyors' Institution, 12, Great George Street, S.W. 8 p.m.

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 7 p.m. (Informal Meeting). Captain P. P. Eckersley, "Broadcasting."

Metals, Institute of, (Scottish Section), 39, Elmbank Crescent, Glasgow. 7.30 p.m Mr. J. A. Gardner, "Methods of Keeping Foundry Records."

Victoria League, 22, Eccleston Square, S.W. 5 p.m. Mr. R. H. Bailey, "Communications of the Empire—the London 'Bus."

Economics and Political Science, London School of, Houghton Street, Aldwych, W.C. 5 p.m. Mr. E. B. Behrens, "International Problems of Industry." (Lecture IV).

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 7 p.m. (Graduates' Section), Mr. K. Rowell, "Recent Developments in Solid Injection Oil-Engines."

University of London, University College, Gower Street, W.C. 5.30 p.m. Lieut.-Comdr. E. Sutton, "Buddhism." (Lecture I).

At King's College, Strand W.C. 5 p.m. Dr. J. A. Hewitt, "Carbohydrate Metabolism." (Lecture IV).

5.30 p.m. Rev. C. F. Rogers, "Ecclesiastical Music." (Lecture III).

5.30 p.m. Mr. S. Smith, "The Nature and Influence of Babylonian Literature."

Transport, Institute of (Midland Section), Chamber of Commerce, Birmingham. 6 p.m. Mr. T. H. Shipley, "Electric Truck Working."

TUESDAY, FEBRUARY 10..Automobile Engineers, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 7 p.m. Mr. F. G. Woollard, "Some Notes on British Methods of Continuous Production."

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof J. Barcroft, "The Colour of the Animal Creation." (Lecture I). "Man."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C. 8.30 p.m. The Rt. Hon. L. S. Amery, "The Economic Development of the Empire."

Anthropological Institute, 50, Great Russell Street, W.C. 8.15 p.m.

Civil Engineers, Institution of, Great George Street, W.C. 6 p.m.

Automobile Engineers, Institution of, Broadgate Café, Coventry. 7.15 p.m. Mr. G. H. Day, "Aluminium and its Alloys." (Graduates' Section).

Marine Engineers, Institute of, 85, The Minorics, E. 6.30 p.m. President's Address.

Asiatic Society, 74, Grosvenor Street, W. 4.30 p.m. Mrs. Ayscough, "Chinese Memorial Temples."

Sanitary Institute, 90, Buckingham Palace Road, S.W. 6 p.m. Major-Gen. Sir Wilfred Beveridge, "Food and Health."

Electrical Engineers, Institution of, (Scottish Centre), 207, Bath Street, Glasgow, 7.30 p.m. Mr. H. W. Taylor, "Three-Wire Direct-Current Distribution Networks. Some Comparison in Cost and Operation."

(North Midland Centre), Hotel Metropole, King Street, Leeds. 7 p.m. Discussion on "Domestic Electrical Apparatus."

(East Midland Sub-Centre), The College, Loughborough. 6.45 p.m. Mr. S. Ferguson, "A General Survey of the High-Tension Switchgear Field."

University of London, University College, Gower Street, W.C. 5.30 p.m. Mr. N. H. Baynes, "Some Aspects of Byzantine Civilisation." (Lecture II).

5.30 p.m. Dr. C. F. Sonntag, "Man's Place in Nature."

At King's College, Strand, W.C. 5.30 p.m. Dr. E. Bevan, "The Hebrew and Greek Idea of God, with special reference to Philo of Alexandria."

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia from 1861." (Lecture IV).

At the Middlesex Hospital Medical School, Cleveland Street, W. 5 p.m. Mr. E. C. Dodds, "The Chemistry of the Internal Secretions." (Lecture III).

Photographic Society, 35, Russell Square, W.C. 7 p.m. Meeting of Scientific and Technical Group.

Transport, Institute of (Graduates' Section), at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C. 5.30 p.m. Mr. H. C. T. Bell, "Inward Traffic Working at a large Goods Station."

WEDNESDAY, FEBRUARY 11..Oriental Studies, School of, London Institution, Finsbury Circus, E.C. 5.15 p.m. Mr. E. Richmond, "Early Moslem Architecture." (Lecture I).

Economics and Political Science, London School of, Houghton Street, Aldwych, W.C. 5 p.m. Mr. J. Adams, "The Principles of Design as applied to Pots and Pans."

University of London, University College, Gower Street, W.C. 5.30 p.m. Mr. I. C. Gröndahl, "Nature Feeling in Norwegian Literature after Wergeland." (Lecture I).

5.30 p.m. Mr. C. R. Sanderson, "Library Resources of London."

6 p.m. Mr. H. Higgs, "The Financial Problems of Europe." (Lecture IV). "Italy and Belgium."

At King's College, Strand, W.C. 5.30 p.m. Sir Thomas Arnold, "Travel and Travellers of the Middle Ages:—Arab Travellers and Merchants, A.D. 1000-1500."

Transport, Institute of (North Western Section), Manchester. 5.30 p.m. Mr. C. Travis, "Railways East of Suez."

Heating and Ventilating Engineers, Institution of, at the Old Colony Club, Aldwych House, Aldwych, W.C. 2.30 p.m. 1. Annual General Meeting. Presidential Address by Mr. A. A. Jones. 2. Mr. A. H. Barker, "Unsettled Questions in Heating and Ventilation."

THURSDAY, FEBRUARY 12..Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p.m.

Embroiderers' Guild, at the Victoria and Albert Museum, South Kensington, S.W. 6 p.m. Mr. A. J. B. Wace, "Greek Embroideries."

Royal Institution, Albermarle Street, W. 5.15 p.m. Prof. Sir William Bragg, "The Properties and Structure of Quartz." (Lecture III).

Mechanical Engineers, Institution of, (North Western Branch), at the Engineers' Club, Albert Square, Manchester. 7.15 p.m. Messrs. L. S. Latham and C. F. Lloyd, "Recent Developments of the Two-Stroke Cycle Heavy-Oil Engine."

Aeronautical Society, 7, Albemarle Street, W. 5.30 p.m. Colonel F. Searle, "The Maintenance of Commercial Air Craft."

Textile Institute, 38, Bloomsbury Square, W.C. 5.45 p.m.

Historical Society, 22, Russell Square, W.C. 5 p.m. Anniversary Meeting. Address by the President, Hon. J. W. Fortescue.

Electrical Power Engineers' Association, Geographical Hall, Deansgate, Manchester. 7.15 p.m. Mr. F. Clegg, "Switchgear."

Electrical Engineers, Institution of, (Irish Centre), Trinity College, Dublin. 7.45 p.m. Mr. J. H. Shaw, "The Services of the Electrical Engineer in the Post Office."

(Dundee Sub-Centre), University College, Dundee. 7.30 p.m. Prof. A. R. Fulton, "The Utilisation of Tides for the Production of Power."

University of London, University College, Gower Street, W.C. 5.15 p.m. Prof. J. E. G. de Montmorency, "African Customary Law, with special reference to Early Egyptian Law." (Lecture IV).

At King's College, Strand, W.C. 5.30 p.m. Prof. W. E. Toothill, "China's Contribution to Western Civilisation."

5 p.m. Dr. R. B. McKerrow, "Bibliographical Notes for Students of English Literature." (Lecture II).

6.30 p.m. Prof. O. Vocadlo, "Czech Civilisation." (Lecture V).

At the Middlesex Hospital Medical School, Cleveland Street, W. 5 p.m. Mr. E. C. Dodds, "The Chemistry of the Internal Secretions." (Lecture IV).

At the Institute of Historical Research) Malet Street, W.C. 5.30 p.m. Prince D. S. Mirsky, "Russian Literature in the Second Half of the Nineteenth Century." (Lecture IV).

FRIDAY, FEBRUARY 13..Royal Institution, Albemarle Street, W. 9 p.m. Dr. Malinowski, "The Forces of Law and Order in a Primitive Community."

Astronomical Society, Burlington House, Piccadilly, W. 5 p.m. Anniversary.

Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W. 6 p.m.

Engineers, Junior Institution of, 39, Victoria Street, S.W. 7.30 p.m.

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 7 p.m. (Informal Meeting.) Discussion on "Gear Production Machinery."

Metals, Institute of (Local Section), at the Sheffield Metallurgical Association, 198, West Street, Sheffield. 7.30 p.m. Dr. C. H. Lander, "Fuel and Its Efficient Utilisation."

(Local Centre), at the University College, Singleton Park, Swansea. 7.15 p.m. Dr. H. Moore, "Season Cracking and its Prevention."

University of London, King's College, Strand, W.C. 5.30 p.m. Prof. E. Prestage, "Vasco da Gama and the Discovery of the Sea Route to India."

5.30 p.m. Mr. N. B. Jopson, "The Early History of the Slavs." (Lecture II).

Physical Society, at the Imperial College of Science, South Kensington, S.W. 5 p.m. 1. Annual General Meeting. 2. Mr. F. E. Smith (President), Address on "A system of Electrical Measurements."

Photographic Society, 35, Russell Square W.C. 7 p.m. Mr. M. Adams, "Concerning Children and Photography."

Textile Institute (Lancashire Section), Burnley. 7.30 p.m. Mr. C. Wilbraham, "Preparation of Coloured Warp Yarn."

SATURDAY, FEBRUARY 14..Royal Institution, Albemarle Street, W. 3 p.m. Prof. W. Rothenstein, "The Artist's Relation to Social and Religious Life." (Lecture I).

London County Council, at the Horniman Museum, Forest Hill, S.W. 3.30 p.m.. Mr. E. Lovett, "Natural History in Folk Lore."

Metals, Institute of, at the Institute of Marine Engineers, 85, The Minories, E. 7.30 p.m. Mr. V. C. Faulkner, "Some Notes on Refractory Materials."

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FRIDAY, FEBRUARY 13, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 16th, at 8 p.m. (Cantor Lecture.) WALTER ROSENHAIN, D.Sc., F.R.S., Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory, "The Inner Structure of Alloys." (Lecture I.)

WEDNESDAY, FEBRUARY 18th, at 8 p.m. (Ordinary Meeting.) J. S. OWENS, M.D., Assoc.M.Inst.C.E., F.G.S., Superintendent, Advisory Committee on Atmospheric Pollution, Air Ministry, Meteorological Office, " Modern Atmospheric Conditions." Sir Napier Shaw, LL.D., Sc.D., F.R.S., will preside.

NINTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 4th, 1925; MR. ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of Council, in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Andrews, Gerald Willoughby, London.
Biles, Sir John Harvard, K.C.I.E., LL.D., D.Sc., M.Inst.C.E., London.
Cohen, Sir Herbert Benjamin, Bt., O.B.E., London.
Collin, James B., London.
Crow, William Roberts, London.
Daniel, W. John, Trivandrum, India.
Nelson, Horatio Whiteway, Bradford, Yorks.
North, William James, Watford, Herts.

The following Candidates were duly elected Fellows of the Society:—

Artis, Cecil Randolph, Norwich.
Atkinson, Llewelyn B., M.I.E.E., London.
Cunnew, George Arthur, London.
Day, Wilfred Ernest Lytton, London.
Fazl, Dr. Sheikh Abul, Ph.D., LL.D., Kapurthala, India.

Forbes, G. A., Kingston, Jamaica, British West Indies.
Herbert, Desmond A., Brisbane, Australia.
Jones, Owen, Melbourne, Australia.
Lawton, Charles Henry, Warminster, Wilts.
Marshall, F. K., Bombay, India.
Napp, Hermann Richard, London.
Powell, Charles Henry, London.
Sen, Lalit Mohan, London.
Stokes, Henry Gordon, Harrow.
Thomas, Major George Frederick, M.C., Tunbridge Wells.
Williamson, William James, London.

The eighth annual Trueman Wood Lecture on " The Stability of Atoms " was delivered by SIR ERNEST RUTHERFORD, O.M., D.Sc., F.R.S.

The lecture will be published in a subsequent number of the *Journal.*

INDIAN SECTION.

FRIDAY, FEBRUARY 6th, 1925; SIR EDWARD A. GAIT, K.C.S.I., C.I.E., Ph.D., in the Chair.

A paper on " Population Problems from the Indian Census," by MR. J. T. MARTEN, M.A., I.C.S., was read by MR. H. R. CROSTHWAITE, C.I.E., C.B.E

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

SEVENTH ORDINARY MEETING.

WEDNESDAY, JANUARY 21ST, 1925.

SIR HERBERT JACKSON, K.B.E., F.R.S., a Vice-President of the Society, in the Chair.

The paper read was :—

IRISH GLASS, OLD AND NEW.

By MRS. GRAYDON-STANNUS.

PART I.

The history of Irish glass, like that of so many other arts connected with the " Ould Country," is a record of wonderful artistic success combined with financial failure. Unfortunately, the earliest records of the industry are lost and it is impossible to speak definitely of the existence of glass houses in Ireland prior to the 16th century. On the other hand there are many old documents in existence which refer to " Glass Workers " and so make it extremely probable that such factories *did* exist, but these documents often consist merely of an old account or a receipt relating to work done, and may use the word "Glass-worker " when they mean a glazier, and such evidence therefore does not establish the fact beyond dispute. However, at the end of the 16th century there undoubtedly was a factory (or " Glass House ") erected in County Cork, in all probability at a spot which even to-day is known as " Glasshouse " and is not far from Curryglass. From that time onwards there are ample evidences of glass houses having been erected in various parts of the country, but in the earliest days of the industry it is extremely difficult to say definitely what particular type of glass any individual factory produced.

When we come to the year 1630 (or thereabouts) we find ourselves on surer ground, as about this time glass was being made on a large scale in Dublin, and that city remained famous for its productions from that date right up to 1896. One of its most noted factories, known as the Round Glass House, was in 1729 and onwards producing really choice specimens, such as dessert dishes (with handles and feet), bowls and goblets, &c., of the most artistic designs and wonderful workmanship. Very beautiful glass, too, was made in Marlborough Street from 1771 onwards by a firm named Williams, who specialised in chandeliers, candlesticks, bowls, decanters, bottles and even bells. A number of factories were afterwards opened which produced every kind of white and coloured glass associated with Ireland. Many fine specimens still exist and mention must be made of Pugh's productions which, though rather late from the collector's point of view are deserving of the highest praise from an artistic standpoint. He was noted for his lustre cutting and his moulded pieces, many of which were very quaint, strongly resembling Bristol but rather heavier in metal and darker in tone. Mention of Bristol reminds me that many of the finest English craftsmen from Bristol, Stourbridge and other places migrated to Ireland when glass-making was flourishing there.

Before, however, we consider the variations in colour, texture, &c., between the different makes of Irish glass, I think we had better pay a fleeting visit to the various localities in Ireland where glass was produced in large quantities.

A factory at Ballycastle in Antrim flourished from 1755 to 1790, its output consisting of bottles, heavy rummers and various kinds of coarse glass of the useful but non-decorative variety.

Belfast figures very largely in the list of glass producing towns and was in the forefront from *circa* 1781 to 1870. It was noted for fine flint glass of heavy character but, so far as my experience goes, white in colour as compared with other Irish products. The cutting of Belfast glass was ornate and deep, and engraving was largely indulged in. It should be noted that glass was sent to Belfast from other parts of Ireland to be decorated, and there is no doubt that foreign engravers were employed there. Very fine candlesticks and lustres were made by a firm named McDowell, mostly of Georgian and Adam designs.

We now return to Cork which was one of the most famous of all Irish glas centres.

As I mentioned just now, records show definitely that a glass house existed in Cork, in the 16th century, but it is impossible to find out what type of glass was made there at that date. In dealing with questions of output, therefore, we can only cover a period extending from *circa* 1782 to 1844, during which time some of the most beautiful glass was manufactured. Here again, engraving was practised and some of the finest gilding was done in Cork. It produced finely cut glass of every description and was famous for rummers and decanters, of both heavy and light varieties. There are still many of the latter in existence and a few of them are marked pieces which place their identity beyond all dispute. These are impressed on the bottom, the most usual markings being " Cork Glass Co." and " Waterloo Co., Cork." Such marked pieces are, of course, greatly sought after by collectors, and are very valuable. I have several in my possession, and have brought one or two to-night for you to see.

I have also brought a card of membership of the Cork Glass Cutters' Union which is of considerable interest. It is, unfortunately, not dated, but it has the name Donovan on it as being the printer, and exhaustive enquiries in Cork have shewn that there has been no printer of that name there for somewhere about 90 years. This fact adds largely to our interest in this card. Apart from the fact that a trades' union existed in Cork 90 years ago, this card shows us some types of glass produced there, and to my mind proves, beyond dispute, that heavy lustre cutting was done in Cork though there are experts who will tell you that that was a Dublin speciality. If lustre or "pillar" cutting was not one of their specialities, why should they have made a point of reproducing it on their trade card ?

Cork was also famous for its engraving, particularly on blown glass, while after 1800 whole dessert services of beautiful colour, and in a great variety of cuttings, were produced, and many are still in existence, though naturally incomplete or made up with Irish glass of later dates.

In 1771 a glasshouse was opened at Drumrea, not far from Dungannon, which specialised in coloured ware—usually known as " Dungannon " glass. It also produced clear glass which was very similar in appearance to Cork, but rather whiter. Its finest coloured products were in green and amber, and comprised bottles, wines, jelly glasses, epergnes and drops for candelabra and chandeliers. Here I may mention that most of the chandelier drops were made in England.

Newry flourished as a glass centre from 1790 to 1847 and specialised in table glass generally of the heavy varieties, both plain and cut. Most of the Newry output was flint glass. One of the earliest glasshouses in Ireland was built on the Stannus property in Portarlington in 1670, but very little is known of its particular productions, and it soon closed down for lack of financial support. If I had been alive then I think its history would have been very different. I am afraid that is very egotistical, but if one can run a glass house successfully in these days in the face of trades' unions, Socialist governments, rings, factory inspectors and other difficulties, I cannot help thinking that our ancestors who paid wages of anything from 6s. to 10s. a week were living in a manufacturer's paradise—only they did not know it.

It was the sort of Heaven we glass manufacturers hope to go to when we die. The heat of the other place will have no terrors for us.

We still have a tumbler in our possession which was made at Portarlington, and I believe some wine glasses still exist, but beyond that I cannot say what particular types of glass the factory was responsible for.

Now we come to the most discussed and most famous of all Irish glass districts, namely, Waterford. It is a peculiar fact that the name Waterford has become imbedded in the public imagination to such an extent that very many people on hearing a reference to Irish glass, say at once, " Oh, you mean Waterford," and are quite surprised to hear that there were other Irish factories as well. It is certain that not more than two or three per cent. of the glass sold as Waterford is genuine and very little of it is even Irish. But on the other hand, it is none the less certain that very large quantities of the most beautiful glass was made there. It was, in fact, more largely exported than other types, and this in itself is one reason why it has been so extensively faked. There is ample evidence of large and continuous consignments of Waterford glass having been dispatched to such places and countries as New York, Newfoundland, Pennsylvania, Barbados, Madeira and the West Indies, to say nothing of France, Spain, Italy, Holland and elsewhere and there is little doubt in my mind that most of the fakes sold in this country come from Holland —copies from originals in Dutch possession. The Waterford factories flourished from 1729 to 1852, with an interval from 1750 to 1780, when the principal works were temporarily closed. All kinds of useful and ornamental glass were made at Waterford, though it is probably most justly famous for its candelabra, chandeliers and its boat shaped and turn-over or helmet bowls, whilst here again, whole dessert services were produced. It is interesting to note, that in my extensive Continental rambles, I have found some of the best specimens of Waterford glass in France. The finest period of manufacture was just after 1780 when the works reopened and the glass was then at its best as regards colour. About 1815 a great deal of heavy step cutting was done at Waterford, but after 1820 the glass began to lose its characteristic colour and certainly became much whiter.

Having completed our tour of the factories I now propose to deal with the characteristics of Irish glass in general as compared with contemporary English productions and foreign and modern fakes of all kinds.

These characteristics can be grouped under the headings of weight, colour, resilience, ring and touch, and we will deal with them in that order, starting with " weight."

Irish glass, except for the blown varieties, is unusually heavy, particularly the early specimens, and that feature is one of our greatest aids when deciding the genuineness of a certain piece. The blown glass as often found in decanters, is, on the other hand, extremely light, but we are helped by the knowledge that these blown pieces in Ireland were hardly ever cut, but either engraved or left perfectly plain, as you will see by these marked Cork blown decanters which I have on show. The engraving is very characteristic and it really varies very little on such pieces, which can be readily recognised and placed. If you examine these decanters carefully and memorise the style of engraving, combined with the misty grey colour, you will be able to pick out a Cork decanter from others when next you see a collection. Similar types of foreign manufacture are frequently marred by sand specks, which are very seldom seen in Irish glass, though air bubbles are often taken for sand specks by the uninitiated. It is important to remember that sand specks are quite opaque, while air bubbles however minute, are transparent, though it may require a magnifying glass to decide the question. However, the chief point to remember is that apart from blown specimens of that type, Irish glass is *heavier* than its competitors.

We now turn to the great question of colour.

All old Irish glass has a peculiar depth of tone, best described as a steel or grey blue, but the early Cork, Waterford and Dublin are particularly distinguishable by this quality. The cause of this grey tone is unknown, but it was probably due to some impurity in the lead used. Countless efforts hav since been made to reproduce it but have been entirely unsuccessful. I myself have carried out the most exhaustive experiments and have made pot after pot from the old recipes in my possession, and Mr. Westropp's, but the results, though of intense interest, only produced a clear white glass.

I have also made analyses of several old bits, and manufactured glass in strict accordance therewith, but the result was always the same—a clear white glass.

I cannot say I am sorry I failed as no lover of Old Irish Glass could be pleased to hear that a piece could be made to-day indistinguishable from the old. Having, however, failed in those experiments I turned my attention to melting down genuine old pieces of very dark colour and on re-casting these I found that they retained most of their lovely and elusive tone in nearly every case.

I will pass round a piece which has retained its colour splendidly, but it has, of course, all the brightness of new glass, the softening film of time having vanished in the melting pot.

There is very little difference in the tone of early Dublin, early Waterford and early Cork glass except that the latter has sometimes, *but not always*, a yellowish tinge which is quite foreign to the other two, and of the three I should say that Dublin glass was darker and heavier.

In my humble opinion a great deal of harm has been and is being done by some people who take every opportunity of stating in print and in conversation that Waterford glass was in reality white and the well-known grey-blue colour is a myth. To this I always say: "Examine marked pieces, visit the Dublin Museum, and go carefully through celebrated collections." There is no doubt that Mr. Westropp, of the Dublin Museum, says Waterford was whiter than other Irish glass. It certainly was after 1820 and at all times was whiter and clearer than Dublin, the early specimens of which are often nearly black. In my opinion a great deal of the fine dark glass attributed to Waterford is in reality Dublin. To illustrate my point I have brought some unique specimens (family pieces), which are known to be Dublin, and if placed on the market to-day would undoubtedly be classified as Waterford.

Surely the safest ground to be on is to examine *marked* pieces of Waterford, which cannot lie. I have here a decanter marked " Penrose, Waterford," which is a lovely colour and very many such pieces have passed through my hands. I think Mr. Westropp's opinion is largely based on a letter written in 1832 by Elizabeth Walpole to an Englishman named Eardley, who had stated that *all* the Irish glass he had ever seen was dark coloured. Mrs. Walpole says she is sending him some Waterford, " so that he can see for himself," which presumably means, see for himself that he was mistaken. Now, that letter was written in 1832, and there is no doubt that at that date, Waterford glass *was* much whiter. But this letter absolutely proves Irish glass was much darker than English. I believe all glass makers were even then, as now, striving to achieve a clear crystal-like glass, which is really what we mean when we talk of " white " glass. But, it should be borne in mind, that the Penrose period was in the 1780's and that is the time when the finest pieces of Waterford were made.

A few years ago I had the privilege of examining the collection of Waterford glass in Mr. Penrose's possession which originally belonged to his grandfather, who owned the glasshouse there. It was quite an education, and what struck one very forcibly was the colour of these beautiful pieces, which greatly resembled old Rose paste.

It is, of course, easily understood why a certain section of the community has seized on the idea that Waterford glass was white. If certain people have a lot of white glass which they wish to sell to Americans and others as Waterford, it is nice to be able to say "Oh, yes, Waterford glass was really white, you know, not a dark colour."

Now, the faker of Irish glass, although he fails to produce the grey tone we have spoken of, is a very enterprising gentleman, with a vivid imagination, so he turns out a variety of blues and greens to suit the taste of amateur collectors who have a very hazy idea of what they are really looking for. Cobalt figures largely in these productions, and a peculiar grey green which, I think, is one of the best swindles on the market. I will now pass round some fakes which have various peculiarities.

A few years ago, when the boom in Irish glass was at its height, the market was suddenly flooded with very shallow heavy bowls of dark colour, many of them of an unpleasant green shade but all bearing the appearance of age. They were badly engraved with trees, hounds and huntsmen, etc., and fetched good prices.

What puzzled me was that they had obviously to an expert eye all been cut down, the tops not having been sheared, nor had they a fire finish; moreover, they were *common bottle glass*. It took some time to solve this fake problem You have probably all seen at one time or another those quaint old siphons consisting of two large globes which were nearly all made from a coarse dark glass. Well, some enterprising person bought all the siphons he could get hold of at a very low price, cut the bottom in two, had them carefully engraved with hunting scenes and sold them as old Irish bowls. On one occasion I was proudly told that the bowl shown me was engraved by Edwards of Belfast fame.

To return to the question of colour, I have never yet found any trace of cobalt in genuine Irish glass and I believe Mr. Westropp has come to the same conclusion. Nor have I ever discovered oxide of copper or iron which, if present, could produce a green tinge. Of course, in this statement I am not referring to green coloured glass but to white glass with a greenish tone. Here, a slight digression may be of interest. Not long ago, in making my modern glass, I had pot after pot of what should have been brilliant white crystal glass, all spoilt by a green tint. This was eventually traced to the fact that the sand, after washing, was left in a shed with a leaky galvanized iron roof, and some rusty water fell into the sand. Those few drops were quite sufficient to cause the trouble, as this defect is due to the presence of iron.

Before leaving the question of colour, we will spend a few moments on that most interesting phenomenon—the " bloom " which is frequently found on early Irish glass. Probably, some scientist present this evening can give us the technical explanation of this peculiarity. All I can do is to state that one often finds on old pieces a soft bloom rather like the bloom on grapes which covers the surface of the glass and which, if cleaned off, will invariably return. It must not be confused with the milkiness often found in old decanters. It certainly adds greatly to the charm of old pieces, and I believe it is due to atmospheric action on impure lead in the glass.

We will now turn to the question of resilience.

There is no doubt that Irish glass is tougher, stronger and more flexible than English; hence its wonderful survival. It takes a severe blow to break it or even chip it, and I have dropped pieces on the floor, before now, which have not suffered in any way as a consequence.

With regard to the question of the touch or feel of Irish glass, we find that it is never harsh or cold, but has a definite warmth and softness, quite its own. But it naturally requires great experience before such a test can be applied with any degree of accuracy in cases where both specimens of glass being tested are of similar quality and age, one being English and one Irish. The best simile I can give you is the difference between hard paste and soft paste in china.

We now come to the ring or sound produced on striking an Irish bowl. As compared with English glass it has a distinct note of its own, which, perhaps, is more accurately described as a vibration between two or three tones which is given forth with a throbbing effect. The ring of English glass is best described as being clearer, brighter and sharper; this test can be proved by striking any piece so shaped that it will ring, but naturally no one would expect a salt cellar or a very thick piece of metal to answer to this treatment.

No paper on this subject would be complete without some reference to the cutting of Irish glass. Speaking generally, we can say that the older the glass the softer and lighter the cutting. Heavily cut pieces are of latish date and I have never found an early piece with hobnail cutting on it.

We will now have some types of cutting thrown on the screen, and I will try to describe them clearly.

Before I conclude the first part of my paper, I should like to refer to a matter which is of great importance to the antique trade of this country, and that is the difficulty of getting genuine pieces of old glass which have been sold to Americans, passed by the American Board of Customs as antique and therefore duty free. We all know how great the difficulties of the Customs are and how much trash has been imported into America in the past as genuine antique, but there should be some means agreed upon between the American Customs Board and some authority in this country by which the proved authenticity of an antique (glass or otherwise) would be accepted by the former. I say "some authority in this country" as I do not know whether it should be done by the Board of Trade, the British Chamber of Commerce, the Federation of British Industries or the Royal Society of Arts. I do not, for one moment, suggest that because I state that a piece of glass is antique, the American Customs should at once agree, but I do say that there should be *some* machinery set up by which a seller of an antique in this country should be able to satisfy the Customs on the other side as to its genuineness. That is not so to-day. If the Customs once turn down a piece there is no effective court of appeal, and I think that one of the bodies I have mentioned should be able to appoint, say, three experts whose decision would be accepted by America. This applies to all antiques—not only to glass.

When I started making modern glass the Press were very kind to me, and referred more or less freely to my new enterprise. Unfortunately, in their enthusiasm, some of them said I was now making replicas of Waterford glass, and this statement was copied in the American Press, with two interesting results. The first was that several really rare pieces of glass I have since sent out there have been turned down as modern, including those two beautiful bowls you see here and those candlesticks.

The other result was equally interesting, and much more amusing. I had a call from an enterprising American gentleman, who said he heard I had discovered how to make Waterford glass and he was prepared to buy at my price. That, of course, shows that the American Customs have to be careful, but they should not have the power of classifying genuine historic antiques as modern. A recent case of importance centred round the famous candelabra of Brocket

Hall, which were purchased at a high price at public auction by our well-known dealer, Mr. Rochelle Thomas, and were turned down by the American Customs, although known to most of the collectors in this country. I am hoping that the Royal Society of Arts may perhaps see its way to take up this important question.

In conclusion I should like to say that I am very grateful to Mr. Dudley Westropp for the tireless energy he has put into his investigations and for all the invaluable data he has collected for our benefit. I am sure all glass lovers will echo my thanks to him.

PART II.

We now come to the second part of my paper, which I see is described as "New Irish Glass." I am not quite sure that this is not rather misleading, as it may convey the impression that my modern glass is made in Ireland. It is, in fact, made in London, and its only right to be described as " Irish " is that it is manufactured from old Irish recipes by Irishmen, and I, myself, am, of course, Irish too. Apart from that and the fact that when things go wrong in the factory—a not uncommon occurrence in glasshouses I believe—I abuse the men in a flood of Irish denunciation in a rich brogue; there is no other connexion whatever between my glass and the Ould Country.

I believe I have been honoured tonight by the presence of a number of glass manufacturers. Some of them have spent their lives in the art, whereas I have been at it for a very short time only, so they will, I hope, understand that I do not expect to add to their knowledge, but, as co-workers in a great industry, my experience as a beginner may possibly interest them. It has always appeared to me that there is a sameness in the designs and cuttings of modern glass, and nothing has given me more pleasure than the enterprise of the Royal Society of Arts in organising competitions with the object of discovering new designs and ideas. I sincerely hope that these competitions will achieve the success they deserve, not so much from the point of view of the number of entrants but the result of their labours. Personally, I am always striving to produce something *new* in design, the recipes I work on being the only *old* part of my little enterprise.

My endeavour is to *create* not to copy.

First and foremost, it must be understood that all the glass turned out by my house is entirely hand-made from start to finish. I have no machinery of any kind in the place but am the fortunate possessor of some very fine old moulds which have become smoothed or softened by years of use. Nothing kills individuality in an artist so much as machinery, and there is no doubt that the men who have made the pieces you see here this evening *are* artists. I realise that there may be some of you to whom this glass will make no appeal. It is difficult to believe that an admirer of the highly cut glass one sees in the shops to-day could possibly like these productions also. However, there is room for both types, my point being that the demand for my glass clearly shows that I am producing something which is wanted.

I will now ask the operator to throw on the screen a series of slides taken from very old drawings showing some of the processes of glass making in a factory confined to hand work only, and very primitive at that. It may surprise you to learn that my little glasshouse is even more primitive.

As soon as the first pieces produced in my factory were ready I showed them to my clientèle for old Irish glass, and I found that they had ideas of their own of the sort of piece they would like to buy. I therefore set to work to give effect to their requirements, and a week after they had asked for a dessert service or a set of candlesticks, I delivered the goods. Now to that extent I have, of course, a great advantage over big manufacturers whose organisation would often be upset by a special order. Naturally a big factory turning out thousands of vases or wines, or whatever it is, all to one pattern must work on a basis of standardisation not only of plant but of men, each man knowing his own particular job. That is quite understandable. But my little business is very different. I do not standardise anything. In fact, I encourage my men to use their own ideas and make things for themselves. They are not always successful, but it is really astonishing to see what artistic ideas are latent in the minds of our workpeople and to what heights they can on occasion rise. That, of course, is what our Society is trying to bring to light in the splendid competitions already referred to. As an example, about three months ago we took on as a helper a little bright eyed rascal from the slums of Lambeth. He showed great interest and promise, and last week during the dinner hour we put him in the chair and told him to " get on with it." He did, and without any supervision or a word of help he produced this piece. Surely that is latent talent which ought to be encouraged. I think a glance at the pieces on show here will make it clear that they represent something "different" from the many similar types of article which one sees in shops today. Being entirely hand-made, no two pieces in a set are exactly alike. There is individuality in every bit.

Then again I feel that most coloured glass made in England has a great sameness about it. There is a blue glass or a green glass and so on. I am trying with some little success to shade colours, getting more of a pastel effect. Any glass manufacturer will realise the difficulty of this, and I have not gone far enough yet to be able to say when the limit so far as shading goes will be reached.

By way of a little more variety as regards mouldings I also tried passing a piece of glass through two or even three moulds, getting an impression of each mould on it with every pleasing results. This again is a very difficult operation, as the article has to be "warmed in" all over between each impression.

I am often asked what is the great difference between my glass and that sent over here from Czecho-Slovakia. The great thing, of course, is that mine is all lead glass and theirs is potash glass, and, secondly, theirs is largely machine-made and lacks to my mind the individuality which my workers are so proud of.

Of course, I am glad when I hear there is a falling off in the sales of Czecho, as I hate to see foreign glass dumped in old England when so many of our own glass workers are walking the streets. I am hoping that Mr. Baldwin will see his way to revive the Safeguarding of Industries Act and also include foreign glass of all grades in its provisions. It would give us a great chance. It may be of interest to mention here that I had the honour of making and presenting to the Queen's Dolls' House the chandeliers, wall lights and table candlesticks. I have here a copy of the chandeliers, for which I had special wheels made to effect the cutting and polishing. These pieces are actually furnace made.

I do not know if I am particularly unfortunate, but it appears to me that in this country every difficulty is placed in the way of any one who is trying to start a new business and so to lessen the amount of unemployment which is so rampant. For instance, I am taking steps to register my trade mark of a harp and the words "Graystan Glass." After a very long wait, I received a set of papers to be filled up and a few days after I returned them I got a letter of which the following is an extract:—

> "I have to refer you to Section 2 of the Trade Marks Acts, 1905 to 1919, which reads as follows:—
>
> > 'It shall not be lawful to register as a trade mark or part of a trade mark any matter the use of which would by reason of its being calculated to deceive or otherwise be disentitled to protection in a Court of Justice or would be contrary to law or morality or any scandalous design.'"

I do not quite understand whether I am to be summoned to a Court of Justice, whether I am immoral or whether my harp design is scandalous; all I know is that I expected every assistance from Government departments. I feel sure that everything possible would be done in Germany for any one who was starting a new business, instead of every difficulty being placed in his way.

Then again I received some months ago from some glass makers in Czecho-Slovakia illustrations of candelabra, wall lights, &c., which they wished to sell me. To my disgust I found that they were copies of photos of old Irish pieces which I published some time ago, so I naturally took no notice of them. Soon afterwards I received a letter asking me to return their illustrations. This I ignored, and ever since then I have been bothered by the London Association for Protection of Trade pressing me to send them back to Mr. Kreiger. I had first of all received a call from the Association, and explained the whole thing to their representative, but to my astonishment he could see no reason why I should refuse to send the illustrations back. What I want to know is—whose trade the London Association is out to protect, English trade or Czecho-Slovakian?

In conclusion I should like to tell you a little story against myself. An American was talking glass to a London dealer not long ago when the latter mentioned my name. The American said " Oh, we all know about Mrs. Stannus's glass. She's an extraordinarily clever woman. She has Waterford glass made in Austria, Holland and other places and sends it over to Ireland.

She dumps it all over the place in cottages and then goes over very ostentatiously in a big car and brings it all back again as wonderful 'finds.'" That may be an American idea of extraordinary cleverness, but I should call it an extraordinarily stupid swindle.

DISCUSSION.

Mr. R. À-Ababrelton said that, with regard to Mrs. Graydon-Stannus's complaint about the official action in connexion with the registration of her trade-mark, she need be in no way apprehensive. All she had to do was to reply, stating that her proposed mark would not come under any of the prohibited heads set out in the section of the Act. It was simply an example of an official way of doing things which must be accepted in this country. A point had occurred to him with regard to the bloom which was found on early Irish glass. As an antiquary he had had a good deal to do with church glass, and very often the same sort of bloom was found on old glass in cathedrals. Mrs. Graydon-Stannus had stated what she considered to be the reason, and he was certainly of opinion that she was quite right. If the attempt was made to manufacture the equivalent of this old glass now, this particular bloom was not forthcoming—at least the glass-makers said they could not get it—and the real truth was that in the old glass there were pieces of lead put in so that the glass could be kept together, and somehow or other the atmosphere in the course of years affected that glass by means of the lead and gave this particular bloom. He had only one other remark to make. Mrs. Graydon-Stannus had referred to Mrs. Walpole's letter to an Englishman named Eardley. He (Mr. à-Ababrelton) believed he was right in saying that Eardley was descended from a Jewish financier named Sampson Gideon, who made a very great deal of money. Sampson Gideon's son changed his name to Eardley, and was made a baronet while he was at Eton, when he was only 14 or 15 years of age. Sampson Gideon's descendant—the Eardley mentioned in the paper—had also changed his name to Eardley. The idea behind this correspondence was that Irish glass at that time was considered inferior as glass because it was not so white as it ought to be, and, therefore, it was attempted to make out that Irish glass was particularly white. Thus it came about that although Eardley wrote and stated that all the Irish glass he had seen was dark in colour, Mrs. Walpole maintained that it was white, and that was how the difficulty came in now, to which Mrs. Graydon-Stannus had referred, that Waterford glass was supposed to be white.

Mr. A. J. Arnold asked whether there was any difference in the fuel employed in the manufacture of modern glass as compared with what was employed in glass-making in the old days. He thought it just possible that the dark colour might be due to something used in the furnaces. Might it be possible that some form of carbon got into the glass in the same way that carbon got into steel? He had often wondered why an elementary research student had not been told off to work on this old glass and get out the different specific gravities and publish the results, in the interests of innocent collectors and honest dealers.

A Member of the Audience asked whether the fuel used in early Irish glass-making was turf, and not wood.

Mrs. Graydon-Stannus said, in reply to Mr. Arnold, that she did not think the fuel could have had much effect. In the old days wood was used, but the fumes of wood could hardly get into the pot. She was convinced that turf was not used, except possibly mixed with wood.

THE CHAIRMAN (SIR HERBERT JACKSON) said he thought it was a good guess to attribute the distinctive colour and feeling of many specimens of Waterford glass partly, at least, to the fuel used, which might very likely have been wood. In the distillation of wood a number of substances were obtained, some of which would not be very powerful reducing agents and might, if they came into contact with the fused glass, give just the amount of dispersal of metallic lead in an extremely fine state of division which could produce a slightly foggy appearance. He had seen a specimen of optical glass in which the foggy blue-grey appearance was very noticeable, and it seemed most likely that this was to be attributed to the reducing action of some of the furnace gases, and occasionally one found glass of fairly high density, containing, say, about 60 per cent. of lead oxide, with that appearance, which was a regrettable defect if the glass was required for optical purposes. It was difficult to say without having specimens of every ingredient used in the glass, but it might be possible, he fancied, with a little practice, to get a somewhat close copy of old Irish glass.

MRS. GRAYDON-STANNUS said that she hoped nobody would get it, not even herself. She also referred to the very curious way in which the glass had retained its colour ; the old Waterford had retained its colour perfectly.

THE CHAIRMAN said that with regard to the remark of Mr. Arnold about glass research, a great deal had been done in this direction ; but it was not easy for the purchaser of a large vessel to take its specific gravity. Often he had not the proper apparatus to do so. Moreover, it was to be doubted whether people who possessed specimens of valuable glass could care to take the risk of handing them over to any but those used to taking the specific gravity of large and easily broken pieces.

With regard to the distinctive character of much of the Irish glass, with its attractive and delicate bluish-grey appearance, it was difficult to say anything definite in the absence of knowledge of the state of purity, or character of impurities, of the ingredients employed by the makers of the glass.

But he must not allow himself to indulge in talking of the manufacture of glass. The Society that evening had had a notable and interesting contribution on this subject of Irish glass. It was extremely pleasant to listen to a discourse of this description from someone who was not only interested in the subject, but who had the feeling which was only possible to those who were themselves workers. One felt that Mrs. Graydon-Stannus had an interest in every piece of glass she handled, and was able to see in her mind the old craftsman working it. He was interested also in the pictures and description of Mrs. Graydon-Stannus's up-to-date (!) factory. She was to be congratulated on the results she had achieved. These results, if they did not have the technical imperfections which added to the beauty of Irish glass, had those individual points which removed the product right away from the sphere of mass production. He did not like to use the term " technical imperfections ; " many pieces of glass in church windows, for instance, would be considered by an ordinary glass manufacturer to be technically very imperfect, but for the purpose of getting feeling and life in the windows, they were not imperfect—one would speak rather of their perfection. He thought it would have been noticed also, that in many of the pieces of this modern manufacture shown there was life and individuality which was very charming. He was sure they would all congratulate Mrs. Graydon-Stannus, not only on her paper, but on the skill she herself had shown, and on the artistic feeling that had enabled her to produce such interesting specimens. He proposed from the Chair a very hearty vote of thanks.

The vote of thanks was carried unanimously.

MRS. GRAYDON-STANNUS said that she was very grateful indeed. She could not thank Sir Herbert sufficiently for all the kindness and indulgence he had shown her when she was starting practically a new industry. He had given her every encouragement. She was grateful to the Society also, and to all those present for their appreciation.

[Many valuable specimens of glass, both old and new, were handed round among the audience, and others were shown on tables for inspection after the meeting.]

NOTES ON BOOKS.

GLIMPSES OF JAPAN AND FORMOSA. By HARRY A. FRANCK. London: T. Fisher Unwin, Ltd. 10*s*. net.

Although Mr. Franck had only "six weeks of scurrying to and fro" in Japan, he has a very quick eye for noticing things of interest and a bright, pleasant way of telling them. He was fortunate, also, in being received as a guest in a Japanese household, and he gives an amusing account of his difficulties in disposing of his trouser-clad legs when squatting on the cushion-scattered matting of a Japanese room, and in similar unfamiliar surroundings.

The author's admiration of the Japanese people is by no means unqualified. The hotel-keepers have a very good idea of plundering their guests, and the tipping system, bad enough in this country and America, seems to have run amok in Japan, where the tips expected often amount to eighty per cent. of the bill. Nor is it the foreigner only who suffers. The town of Yamada is a sort of Mecca to which in the spring time pilgrims resort in enormous numbers, and the local guide book explains that "the occupation of the people of Yamada is to feed peacefully upon pilgrims."

The Japanese sense of discipline, excellent as it may be in moderation, becomes anything but admirable when it is so developed that it paralyses initiative and renders men unable to act except on definite orders. Thus, at the great earthquake and fire of 1923, the captains of Japanese warships and liners in Yokohama Harbour refused to rescue their own countrymen who appealed to them for help until they received official instructions to do so, and this in spite of the fact that ships of other nations were doing their very utmost to save the unfortunate Japanese.

The second half of the book deals with Formosa, a country which loses nothing in point of interest from the fact that its secrets are so jealously guarded against foreigners. Mr. Franck contrived to see a good deal of the island and its various industries, at the head of which comes camphor. Formosa to-day produces nine out of the twelve million pounds of camphor which the world consumes annually, and as Japan proper produces two millions more, it will be seen to what an enormous extent our Eastern ally controls the supply of this article. A vast number of camphor trees grow in the country of the head-hunting savages of the interior. It seems almost incredible that in an island of this size—Formosa is but 257 miles long—the primitive head-hunters should be able to maintain themselves against all the modern resources of the Japanese; but such is the nature of the country—of which Mr. Franck gives a vivid description—that, although the "guard-line" is constantly being pushed forward, its advance is so slow that it will probably be many years before the last of the savages can be said to be civilised.

GENERAL NOTES.

Moroccan Wool Industry.—There are three classes of Moroccan wool—Aboudia, Urdighia, and Beldia—according to a report by the United States Consul at Casablanca. The most recent census places the number of sheep in the country at about 5,000,000, of which approximately 4,050,000 are wool-bearing. About 300,000 produce 1,125,000 pounds of Aboudia wool; 450,000 yield a clip of about 1,685,000 pounds of Urdighia wool; and 3,300,000 supply approximately 13,000,000 pounds of Beldia wool. A large part of the production is used at home for the needs of local industries in the weaving of cloth for native garments and in the manufacture of rugs. The annual exportation of wool from Morocco from 1912 to 1923 averaged approximately 6,283,000 pounds.

Assistance to Sericulture in Kwangtung.—According to a report by the United States Trade Commissioner at Shanghai, the Government of Kwangtung Province has authorised the organisation of a bureau for assisting the people in the improvement of the provincial sericulture. The bureau, which is closely affiliated with the Lingnaam Agricultural College, has power to supervise all the work of certified egg production in the Province, even to the point of licensing egg merchants. It is supported by appropriations from the provincial government, and has as adviser a board composed of representatives from the Government, the college, and several organisations of business men who are interested in the silk industry.

MEETINGS OF THE SOCIETY TO MARCH 11, 1925.

Ordinary Meetings.

Wednesday evenings, at 8 o'clock, unless otherwise announced:—

February 18.—J. S. Owens, M.D., Assoc. M.Inst.C.E., F.G.S., Superintendent, Advisory Committee on Atmospheric Pollution, Air Ministry, Meteorological Office, "Modern Atmospheric Conditions." Sir Napier Shaw, LL.D., Sc.D., F.R.S., will preside.

February 25.—Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., "The Power of Internal Combustion Engines for Motor Cars." The Hon. Sir Charles A. Parsons, K.C.B., LL.D., D.Sc., F.R.S., will preside.

March 4.—Professor W. E. S. Turner, O.B.E., D.Sc., F.Inst.P., Department of Glass Technology, University of Sheffield, "The Modern Production of Sheet-Glass."

March 11.—Emile Cammaerts, "The Restoration of Public Buildings in Belgium." Viscount Burnham, C.H., LL.D., will preside.

Indian Section.

Friday afternoon, at 4.30 o'clock:—

March 6.—Sir Henry Sharp, C.S.I., C.I.E., M.A., "The Development of Indian Universities." The Rt. Hon. Viscount Chelmsford, G.C.S.I., G.C.M.G., G.C.I.E., G.B.E., will preside.

Dominions and Colonies Section.

Tuesday afternoon, at 4.30 o'clock:—

February 24.—R. H. Brackenbury, Member of the Empire Cotton Growing Corporation Mechanical Transport Sub-Committee, "Transport in Tropical Africa." Major-General Sir Ernest D. Swinton, K.B.E., C.B., D.S.O., R.E., will preside.

CANTOR LECTURES.

Monday evenings, at 8 o'clock :—

WALTER ROSENHAIN, D.Sc., F.R.S., Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory " The Inner Structure of Alloys." Three Lectures. February 16, 23, March 2.

SYLLABUS.

LECTURE I.—FEBRUARY 16.—Structure of Metals and Alloys. Micro-structure and Atomic Structure. Meaning of Micro-structure. Constitution of Alloys. Pure Metals, Compounds and Solid Solutions. Occurrence in Alloy Systems. Equilibrium Diagrams. Crystalline Nature of Metals. Atomic Structure of Crystals. X-ray Study of Crystals. Space Lattices and Structure of Pure Metal Crystals.

LECTURE II.—FEBRUARY 23.—Nature of Solid Solutions. Possible Arrangement of Atoms. Proof of the Substitution Hypothesis. Theory of Lattice Distortion. Melting and Freezing. Lattice Expansion, local and general. Lattice Compression and Rise of Melting Point. Strength and Ductility. Lattice Distortion under Stress. Slip and Amorphous Layers. Inter-Crystalline Boundaries.

LECTURE III.—MARCH 2.—Electrical Conduction. Passage of Electrons through Atomic Lattice. Effect of Distortion and Thermal Agitation. Super-Conductivity. Other effects of Distortion. Colours of Alloys. Magnetic Properties. Solid Solutions with no Distortion. Inter-metallic Compounds. Difference from " Symmetrical Solid Solutions." General Bearing on Scientific Metallurgy. Structure of Complex Alloys. Balancing Distortion. Calculation of Equilibria.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, FEBRUARY 16. .Cold Storage and Ice Association, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 5.30 p.m. Mr. J. Raymond, " The Importance, from a National and Industrial Point of View, of extending Refrigerating Instruction in Educational Systems throughout Great Britain."

Geographical Society, Kensington Gore, S.W. 5 p.m.

British Architects, Royal Institute of, 9, Conduit Street, W. 8 p.m. Mr. D. S. McColl, " Sculpture in Relation to Architecture."

Electrical Engineers, Institution of, (Local Centre), at The University, Liverpool. 7 p.m. Mr. W. E. Bush, " Modern Electric Lighting Practice."

Faraday Society, at the Chemical Society, Burlington House, Piccadilly, W. 8 p.m. 1. Messrs. A. J. Allmand and V. S. Puri, " The Effect of Superposed Alternating Current on the Anodic Solution of Gold in Hydrochloric Acid." 2. Mr. C. H. Desch and Miss Eileen Vellan, " The Electrolytic Deposition of Cadmium and other Metals on Aluminium." 3. Messrs. W. M. Thornton and J. A. Harle, " The Electrolytic Corrosion on Ferrous Metals." 4. Mr. S. Glasstone, " Overvoltage and Surface Forces at the Lead Cathode." 5. Mr. M. Shikata, " The Electrolysis of Nitrobenzene with the Mercury-dropping Cathode." 6. Mr. J. R. Coutts, " The Law of Distribution of Particles in Colloidal Suspensions: A Note on the Specific Volume of a Gamboge Suspension." 7. Mr. W. W. Barkas, " On the Distribution of Particles in Colloidal Suspensions."

Economics and Political Science, London School of, Houghton Street, Aldwych, W.C. 5 p.m. Mr. E. B. Behrens, " Organising an International Civil Service for purposes of Industrial Research."

University of London, University College, Gower Street, W.C. 5.30 p.m. Lieut.-Comdr. E. Sutton, " Buddhism." (Lecture II).

At King's College, Strand, W.C. 5 p.m. Dr. J. A. Hewitt, " Carbohydrate Metabolism." (Lecture V). 5.30 p.m. Dr. R. W. Seton-Watson, " The Origins of the War in its Balkan Aspect." (Lecture I).

5.30 p.m. Rev. C. F. Rogers, " Ecclesiastical Music." (Lecture IV).

5.30 p.m. Prof. A. E. Jolliffe, " Early Mathematics before Newton."

At St. Bartholomew's Hospital Medical College, West Smithfield, E.C. 5 p.m. Sir William I. de Courcy Wheeler, " Some Practical Considerations and Experiences in the Conservative Treatment of Fractures of the Pelvis and the Lower Extremity." (Lecture I); continued on the 17th, 18th and 19th February.

TUESDAY, FEBRUARY 17. .Statistical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 5.15 p.m. Messrs. L. J. Russell and T. Edser, " The Fishery Statistics of England and Wales."

Electrical Engineers, Institution of, (N. Western Centre) Engineers' Club, Albert Square, Manchester. 7 p.m. Mr. H. W. Clothier, " The Design of Electrical Plant-Control Gear and Connections for Protection against, Shock, Fire and Faults."

(Scottish Centre), Freemasons' Hall, Edinburgh. 7.45 p.m. Prof. G. W. O. Howe, " World-Wide Radio Telegraphy." (Faraday Lecture).

Textile Institute, Manchester. 7 p.m. Prof. Slater, " The Application of an Electrical Method to the Study of the Moisture Absorption in Cotton."

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. J. Barcroft, "The Colour of the Animal Creation," (Lecture II), "The Hare."

Photographic Society, 35, Rbssell Square, W.C. 7 p.m. Meeting of Kinematograph Group.

Transport, Institute of, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C. 5.30 p.m. Mr. H. B. Davies, "The Rights and Duties of Transport Undertakings."

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. J. E. G. de Montmorency, "The Significance of the Humanism of the Negro Races."

5.30 p.m. Mr. N. H. Baynes, "Some Aspects of Byzantine Civilisation." (Lecture III).

At King's College, Strand, W.C. 5.30 p.m. Miss E. Underhill, "The Philosophy of Religion, The Realism of the Mystics."

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m Sir Bernard Pares, "Contemporary Russia from 1861." (Lecture V).

At the Middlesex Hospital Medical School, Cleveland Street, W. 5 p.m. Mr. E. C. Dodds, "The Chemistry of the Internal Secretions." (Lecture V).

Wednesday, February 18.. Meteorological Society, 49, Cromwell Road, S.W. 7.30 p.m. 1. Miss L. D. Sawyer, "The Effect of Pressure Distribution upon London's Sunshine in Winter." 2. Prof. S. Chapman, "On the Changes of Temperature in the Lower Atmosphere, by Eddy Conduction and Otherwise." 3. Messrs. N. K. Johnson and O. F. T. Roberts, "The Measurement of the Lapse Rate by an Optical Method."

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. (Students' Meeting.) Mr. R. H. Tangri, "Reconstruction of Barrow Haven Bridge, Lincolnshire, L. & N.E. Rly."

Sanitary Institute, Swansea. 1. Prof. A. L. McIlroy, "Maternal Mortality." 2. Prof. Bacon, "Smoke Abatement."

Oriental Studies, School of, London Institution, Finsbury Circus, E.C. 5.15 p.m. Mr. E. Richmond, "Early Moslem Architecture." (Lecture II).

Economics and Political Science, London School of, Houghton Street, Aldwych, W.C. 5 p.m. Mr. J. Thorp, "The Principles of Design as Applied to Books and Printing."

Electrical Engineers, Institution of (S. Midland Centre), at the University Birmingham. 7 p.m. Mr. H. W. Clothier, "The Design of Electrical Plant, Control Gear and Connections for Protection against Shock, Fire and Faults."

(Local Sub-Centre), at the Royal Victoria Hotel, Sheffield. 7.30 p.m. Address by the President, Mr. W. B. Woodhouse.

University of London, University College, Gower Street, W.C. 5 p.m. Dr. A. S. Parkes, "The Physiology of Reproduction." (Lecture V).

6 p.m. Mr. H. Higgs, "The Financial Problems of Europe." (Lecture V)., "Great Britain and Ireland."

5.30 p.m. Mr. I. C. Gröndahl, "Nature Feeling in Norwegian Literature after Wergeland." (Lecture II).

5.30 p.m. Miss E. S. Fegan, "Library Resources Outside London."

At King's College, Strand, W.C. 5.30 p.m. Baron A. F. Meyendorff, "Travels in the East, A.D. 800-1200"

At St. Bartholomew's Hospital Medical School, 6, Giltspur Street, E.C. 5 p.m. Dr. J. M. D. Scott, "The Medullary Centres." (Lecture II).

Thursday, February 19.. Aeronautical Society, at the Royal Society of Arts, John Street, Adelphi, W.C. 7 p.m. (Joint Meeting with the Institution of Automobile Engineers). Lieut.-Col. L. F. R. Feli, "Light Aeroplane Engine Development."

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. Sir William Bragg, "The Properties and Structure of Quartz." (Lecture IV).

Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p.m.

Victoria and Albert Museum, South Kensington, S.W 6 p.m. Mr. G. H. Palmer, "Book Bindings."

Linnean Society, Burlington House, Piccadilly, W. 5 p.m. 1. Miss A. Lorrain Smith, "John Templeton's Drawings of Lichens and Mosses." 2. Dr. J. Burtt-Davy. "The Tropical African Element in the Arborescent Flora of the Transvaal." 3. Prof. R. R. Gates, "Virescent Inflorescence of Delphinium."

Chemical Society, Burlington House, Piccadilly, W. 8 p.m.

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

Child Study Society, 90, Buckingham Palace Road, S.W. 6 p.m. Mr. F. M. Alexander, "An Unrecognised Principle in Human Behaviour."

Mechanical Engineers, Institution of, (N. Western Branch), at the Engineers' Club, Manchester. 7 p.m. Mr. H. W. Baker, "The Use of the Dalby-Watson Form of Indicator for the High Speed Petrol Engine."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. Major E. I. David, "Electricity in Mines."

University of London, University College, Gower Street, W.C. 5.30 p.m. Dr. C. Pellizzi, "Il Giannone e i Pensatori politici napoletani del secolo XVIII." (In Italian).

5.15 p.m. Prof. J. E. G. de Montmorency, "African Customary Law, with special reference to Early Egyptian Law." (Lecture V).

At King's College, Strand, W.C. 5.30 p.m. Dr. I. P. Bruce, "Education in China."

5 p.m. Dr. R. B. McKerrow, "Bibliographical Notes for Students of English Literature." (Lecture III)

6.30 p.m. Dr. O. Vocadlo, "Czech Civilisation." (Lecture VI).

5.30 p.m. Dr. P. C. Buck, "The Laws and Assumptions of Music." (Lecture II).

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Prince D. S. Mirsky, "Russian Literature in the Second Half of the Nineteenth Century." (Lecture V).

At the Middlesex Hospital Medical School, Cleveland Street, W. 5 p.m. Mr. E. C. Dodds, "The Chemistry of the Internal Secretions." (Lecture VI).

Friday, February 20.. Engineering Inspection, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 7.45 p.m. Major C. E. S. Phillips, "The Radium Industry, its Development and Importance."

Royal Institution, Albemarle Street, W. 9 p.m. Prof. T. H. Pear, "Acquiring Muscular Skill."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. A. C. Banfield, "Photography by Artificial Light."

Sanitary Institute, at the University, Edmund Street, Birmingham. 7.30 p.m. Prof. J. Robertson and Mr. C. G. Teale, "Fresh Air and Light in the Treatment and Prevention of Disease."

Aeronautical Engineers, Institution of, at the Engineers' Club, Coventry Street, W. 6.30 p.m. Prof. E. G. Coker, "Photo-Elastic Methods of Measuring Stress."

Electrical Engineers, Institution of, (S. Midland Centre), Joint Meeting with local centres of the Institutions of Civil and Mechanical Engineers, City Council Chambers, Birmingham. 7 p.m. Address by the President, Mr. W. B. Woodhouse.

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 6 p.m. Annual General Meeting.

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. W. A. Phillips, "Loan-Slavery in Latin America."

At King's College, Strand, W.C. 5.30 p.m. Mr. N. B. Jopson, "The Early History of the Slavs." (Lecture III.)

China Society, at the School of Oriental Studies, Finsbury Circus, E.C. 5 p.m. Mrs. Ayscough, "The Symbolism of the Purple Forbidden City."

Engineers, Junior Institution of, 39, Victoria Street, S.W. 7.30 p.m. Mr. J. M. Seddon, "Inverted Tooth Chain Drives."

Saturday, February 21.. Royal Institution, Albemarle Street, W. 3 p.m. Prof. W. Rothenstein, "The Artist's Relation to Social and Religious Life." (Lecture II).

London County Council, at the Horniman Museum, Forest Hill, S.E. 3.30 p.m. Mr. F. Balfour-Browne, "My Journey to Brazil."

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FRIDAY, FEBRUARY 20, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 23rd, at 8 p.m. (Cantor Lecture.) WALTER ROSENHAIN, B.A., B.C.E., D.Sc., F.R.S., Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory, " The Inner Structure of Alloys." (Lecture II.)

TUESDAY, FEBRUARY 24th, at 4.30 p.m. (Dominions and Colonies Section.) R. H. BRACKENBURY, Member, Mechanical Transport Sub-Committee, Empire Cotton Growing Corporation, " Transport in Tropical Africa." Major-General Sir Ernest D. Swinton, K.B.E., C.B., D.S.O., R.E., will preside. Tea and coffee will be served in the Library at 3.45 p.m.

WEDNESDAY, FEBRUARY 25th, at 8 p.m. (Ordinary Meeting.) SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., " The Power of Internal Combustion Engines for Motor Cars." THE HON. SIR CHARLES A. PARSONS, K.C.B., LL.D., F.R.S., will preside.

COUNCIL.

A meeting of the Council was held on MONDAY, FEBRUARY 9th. Present :— Lord Askwith, K.C.B., K.C., D.C.L., in the Chair ; Mr. A. Chaston Chapman, F.R.S. ; Sir William Henry Davison, K.B.E., D.L., M.P. ; Rear-Admiral James de Courcy Hamilton, M.V.O. ; Col. Sir Arthur Holbrook, K.B.E. ; Sir Herbert Jackson, K.B.E., F.R.S. ; Major Sir Humphrey Leggett, D.S.O., R.E. ; Sir Philip Magnus, Bt. ; Mr. Alan A. Campbell Swinton, F.R.S. ; Dr. J. Augustus Voelcker, M.A., Ph.D. ; and Sir Philip Watts, K.C.B., LL.D., F.R.S., with MR. G. K. Menzies, M.A. (Secretary of the Society) and MR. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

Sir Charles H. Armstrong was appointed a Vice-President of the Society in place of Sir Thomas Jewell Bennett, deceased.

Preliminary consideration was given to the question of the award of the Albert Medal for 1925.

Arrangements were made for the investment of the funds in connexion with the Thomas Gray Memorial Trust.

A number of papers and courses of lectures proposed for the latter end of this session and the earlier part of next session were considered.

Other formal business was transacted.

TENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 11TH, 1925.

LORD BEARSTED, LL.D., a Vice-President of the Society, in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Bennett, James Henry, M.I.Mar.E., Sheffield.
Cayley, Bernard Briggs, London.
Cayley, Percy John, Croydon.
Lancaster, Thomas Alfred, Barnston, Birkenhead.
Murrell, Frank, Weston-super-Mare.
North, Robert Benson, Junr., Watford.
Paul, Robert William, M.I.E.E., London.
Rickaby, Tom Walton, London.
Sell, Donald Frank, London.
Standfield, Frank, Assoc.M.Inst. C.E., Surbiton, Surrey.
Truscott, Sir George Wyatt, Bt., London.

The following Candidates were duly elected Fellows of the Society:—

Baker, Reginald Percy, London.
Bolton, Herbert Cookson, London.
Hammond, Miss Winifred, London.
Leefe, B. W., London.
Logsdon, Stanley E., Pernambuco, Brazil.
Uddin, Ahid, London.
Whittaker, William Thomas, London.

A paper on "The Diesel Engine in Navigation" was read by SIR J. FORTESCUE FLANNERY, Bt., Past-President of the Institute of Marine Engineers.

The following took part in the discussion:—THE RIGHT HON. THE EARL OF BIRKENHEAD, H.E. THE JAPANESE AMBASSADOR, and ENGINEER-VICE-ADMIRAL SIR Robert Dixon, K.C.B.

The paper and discussion will be published in a subsequent number of the *Journal.*

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PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION

TUESDAY, JANUARY 27TH, 1925.

SIR HALFORD JOHN MACKINDER, M.A., in the Chair.

A letter was read from the Secretary of State for the Colonies expressing regret that, owing to a previous engagement, he was unable to be present, and adding that the subject was one in which he was much interested.

THE CHAIRMAN said that, unfortunately, he would be unable to remain to hear the whole of the discussion on the paper which would subsequently take place. He hoped, therefore, he might be allowed to make a few remarks before the paper was read. The subject of the paper had a double aspect. The author was interested, as far as he could gather, in the theory of a service of intelligence in regard to the Empire which he would like to see developed on a particular basis, and also he was a man of experience in tropical conditions and was contemplating further studies which would no doubt have important results. One of the most interesting points for consideration at the present time was the fact that most advance seemed to take place on the borders between sciences, or, as it was sometimes called, the cross-fertilisation of sciences. Every one was familiar with the immense advances of knowledge that had been made due to the fact that the old sharp distinction between chemistry and physics was no longer maintained, and the same phenomenon was apparent in many other directions. In the particular case under discussion the author drew attention to the interaction of ideas in research derived, on the one hand, from the study of geography, and, on the other hand, from the study of economics. There was a time when, in connexion with geography, he (the Chairman) used to delight in attacking papers at various gatherings which were concerned with the definition of the subject—exactly what geography was, whether it was a science, or an art, or a mere "graphy." He was afraid he had now lost a good deal of his interest in those things. In going through life one found that the information stored in one's mind at the start was pulled out from its pigeon-hole and was not always put back into the same pigeon-hole. The pigeon-holing of knowledge was much more prevalent a generation ago than it was to-day, but there was no question that, however vain it might be to try and define a subject nowadays, there were points of view which were exceedingly valuable if compared. He remembered a passage in one of Walter Bagehot's books in which the author reminded his readers that, if they went to the top of St. Paul's Cathedral and looked out on the buildings of the City of London, and then moved to the top of the Monument they would see the same buildings arranged differently, with the result that those who made the journey would understand a great deal more of London. He thought it was vitally important that there should be men in this country equipped, not merely as specialists, but with at least two, if not three, specialities; and he believed that such men were quite as likely to make advances of knowledge as the men, no doubt equally meritorious, who devoted themselves to a single subject, and put blinkers on in order that they might penetrate as far as they possibly could in a single direction. Above all was that necessary when a man was sent out to make observations in foreign countries. He, of all people, must not be the slave of a single speciality. Personally, he could conceive of no better equipment for a man sent out to compile information for the benefit of the Governments of the Empire and for the benefit of commercial enterprise than that he should be equipped as a trained economist and also as a geographer. Such a man would see into things as well as merely see them, and by being possessed of the physical knowledge, which was the basis of geography, and social knowledge, which was of the essence of economics, he would in all probability be able to produce results. In the paper the author instituted a comparison between two tropical portions of the British Empire, British Guiana in South America, and Malaya at the back of Singapore. He would not anticipate what the reader of the paper was going to say, but he thought that what would be in the minds of every one present was that a man who, like the author, had been Professor at the Imperial College of Tropical Agriculture in the Island of Trinidad, when he went to Malaya or some neighbouring region to institute comparisons would probably render service to the land in which his studies were previously pursued. He thought another idea that would be at the back of all their minds was how wonderful the British Empire was, and not the least wonderful in its tropical portions. That a little patch on the map of the world, British Guiana, should be as large as the British Islands, should be practically virgin forest of the tropical rain type, and should be hardly inhabited except just along the coastal front, gave much food for thought. He did not know whether those present had ever considered what were the possibilities of the tropics. The island of Java, which was not so large as British Guiana, had a population of between 40 and 50 millions. It lay pretty nearly in the same latitude as British Guiana and was under the conditions of tropical rain If the Malay Archipelago were inhabited with the same density that Java was to-day it would have a population of 400 million people; the forest of the Congo would carry another 400 million people, and the tropical portions of Brazil and British Guiana would carry another 400 million people. It was not necessary that that population should be wholly resident in those regions. The people in temperate regions eat food that came from a distance, and in that connexion the reserves of the British Empire were worth considering. The author in his paper drew attention to a relatively developed region in the Malayan area and to an undeveloped region in British Guiana, and argued that by proper study, by proper thought beforehand, by proper planning, by the investment of capital and scientific research it should be possible to develop British Guiana to the same extent as Malaya. The author would argue that geographical circumstances had favoured a development of Malaya first; but personally he asked them to remember that the strength of the British Empire lay largely in the fact that it not only had regions that were relatively developed but immense reserves of territory, both tropical and temperate, which were practically undeveloped. The problem of the next generation was to develop those areas, retaining them within the British Empire, and supplementing the small area of the British Islands by the vast Empire. That gave a new hope for the race.

The paper read was :—

ECONOMIC RESEARCH IN TROPICAL DEVELOPMENT,

WITH SPECIAL REFERENCE TO BRITISH GUIANA AND BRITISH MALAYA.

By W. R. Dunlop.

In describing the point of view and methods dealt with in this paper as economic research, I run the risk of being misleading to academic economists, for what I am electing to call economic research is really research in economic geography and industrial and administrative efficiency. Economic research in the academic sense is the unravelling of the interacting human circumstances that give rise, or tend to give rise, to business phenomena, such, for example, as changes in price levels. The present Food Commission in this country is, to some extent, I suppose, engaged in work of this nature. The science, which has been evolved by generalising on economic phenomena and tendencies is called economics, familiar phrases in connexion with which are supply and demand, elasticity of demand, trade cycles and division of labour. I define economics briefly as the abstract science of man in relation to his business activities, and its importance to us in this paper rests in the idea that it describes those economic principles and tendencies which will pervade and arise from our more concrete considerations.

A good deal of thought has been devoted to the question as to what is the realistic basis of economics. It is far outside of the scope of this paper to enter into a discussion of this question, but I am inclined to think that it will be found profitable to regard the first, though not necessarily the ultimate bases as being geography and human psychology. After all, the fundamental question of economics is why some of us, individually or collectively, are better off than others, and the answer to this is to be found, I think, in geographical environment and in human ability and idiosyncrasies.

Regarded from this point of view, research in economic geography and industrial efficiency underlies economics even if it may not be economics in the pure academic sense. In common with economics our main objective is the study of man, and it is very important to realise that this does not hold good in the case of the applied natural sciences which borrow the derived adjective economic. Thus although economic botany, economic geology and economic entomology are concerned respectively with the study of plants, minerals and insects in relation to man's wealth, and greatly assist production, they are not economic studies. They consider Nature in relation to man, not man in relation to Nature, which, broadly speaking, is geography. Furthermore they deal only with certain specialised aspects of Nature, whereas in economics of the geographical kind we consider man in relation to all aspects of Nature, both favourable and unfavourable. An example of an unjustified use of the word economic may be quoted to make what I mean clearer. Our South American Colony, British Guiana—concerning which I shall have a good deal to say in a few minutes—is initiating, or has initiated what is officially called an " economic survey " consisting of a systematic exploration by specialists of the latent resources of a certain region in respect of soil fertility, timber, minerals and water-power. This is not an economic survey, but a survey in economic botany and geology—a very different thing. Even engineering, in spite of its revolutionary economic effects, is not economics ; it is industrial physics and mechanical invention.

I bring these points to your notice, not because I wish to quibble over names, but because I wish to emphasise a point of view which I know from experience is not appreciated, principally, I think, because it is new. The idea that I am driving at is the co-ordinating "something" which is missing, or needs developing, between specialised natural science and academic economics. I call it economic geography and industrial and administrative efficiency. A shorter phrase might be economics on a geographical basis, and it should be scarcely necessary for me to add that research in this direction necessitates intimate contact with and the co-operation of industrial and commercial interests and Governments, and on the part of the investigator, a wide range of knowledge, a broad practical outlook, and a sound familiarity with those special subjects like statistical method and accountancy which enable us to measure economic distributions and efficiency.

I believe in practical illustration rather than theoretical discussion for such a matter as that which we have in hand, and I propose, by contrasting the conditions in two of our tropical Dependencies, to show you actually, though necessarily briefly and superficially, what I mean. But I must, in the first instance, explain shortly why, as the title of this paper implies, I am especially advocating geographical economic research for the Tropics. My reasons are these: firstly, because our tropical possessions are so numerous, so far-flung and differ so enormously in most respects; secondly, because, with all respect to our geographers, their conditions have never been systematically analysed and compared; thirdly, because they are, for the most part, only partially developed in every sense, which affords scope for actually applying results and conclusions; and lastly, because we stand ultimately responsible for them and should therefore exercise our highest intellectual powers in their interests.

BRITISH GUIANA AND BRITISH MALAYA COMPARED.

If the fundamental question of economics is why some of us are better off than others, we ought to get some interesting results in our tropical world by contrasting a country which is poorly off and cannot develop in spite of available resources, with another country which is well off and fairly extensively developed. Wealth, like health, is, of course, a relative condition, but for the purposes of this paper I have decided to select British Guiana, in the New World Tropics, as falling within the former category, and British Malaya, of the Old, as coming within the latter. I imply nothing detrimental to British Guiana in calling her poorly off and unable to develop; in fact, I am only repeating what can be found in her own published announcements.

In making the comparison, however, we have to bear in mind that wealth is the result of the profitable production and exchange of commodities and services, and that development is the gradual unfolding and organisation of resources needed to bring this about, and finally, that there is all the difference between the total wealth of a country as a national unit and the wealth per head of a country's inhabitants. These distinctions are not of immediate importance as we shall be concerned first with general geographical characteristics.

The relative positions and areas of British Guiana and British Malaya are shown on the Mercator's projection of the world in front of you.

As countries go, both are comparable in size, the area of British Guiana being roughly equal to the combined area of England, Scotland and Wales, while the area of British Malaya roughly corresponds to the combined area of England and Wales alone. The difference between the two countries as political units I shall make clear later. In regard to physical conditions the two countries have many features in common. Both lie within a similar range of latitude (between 1° and 9° north of the Equator), and what is of greater importance, they lie respectively in the two great tropical regions of maximum rainfall of over 80 inches per annum. Both enjoy sea breezes, especially British Guiana. The natural vegetation of each is, for the most part, dense tropical rain-forest, and in both malaria, ankylostomiasis (hookworm) and other human diseases constitute a factor inimical to health and natural increase of population. Both countries are mountainous in the interior with maximum elevations of about 7,000 to 8,000 feet. These mountains are sandstone or granitic in character, and are not volcanic. Both countries possess extensive deposits of valuable minerals. The soil, on the whole, is exceedingly fertile in both countries. Desert conditions are entirely absent. The rivers are numerous and large, and water-power is abundant, especially in British Guiana. As regards population, the inhabitants of each country are principally immigrants of recent or ancient arrival, by which I mean that the inhabitants, for the most part, are not indigenous or aboriginal. The Indian (India) element in each is of great and special economic importance.

We now come to the general dissimilarities. These are exceedingly important because they are likely to show us what, for the present, we are seeking, namely, why one country, as a political unit, is more extensively developed than the other.

But let us first consider the extent of this difference in development.

In British Malaya about 60 per cent. of the country's total area is under systematic occupation (I include the Government forest reserves in this figure); whereas in the case of British Guiana less than 2 per cent. is under occupation, and most of that of an exploitary nature.. In British Malaya about 9 per cent. of the total area of the country is under agriculture, whereas in British Guiana only about 0.25 per cent. is thus developed. British Malaya has 2,460 miles of metalled roads and 1,092 miles of first-class railway, whereas British Guiana, one-fifth larger in area, has only 447 miles of metalled roads (including municipal) and only 97½ miles of not very prosperous railway. As regards harbour facilities, Singapore, the chief Malayan port, next to Liverpool in tonnage-entry, can receive 20,000 ton steamers at the wharves at any state of the tide, whereas Georgetown harbour, in British Guiana, cannot receive steamers of more than 3,000 tons, and then only at high water. Finally, the value of the exports from British Malaya in 1923 was

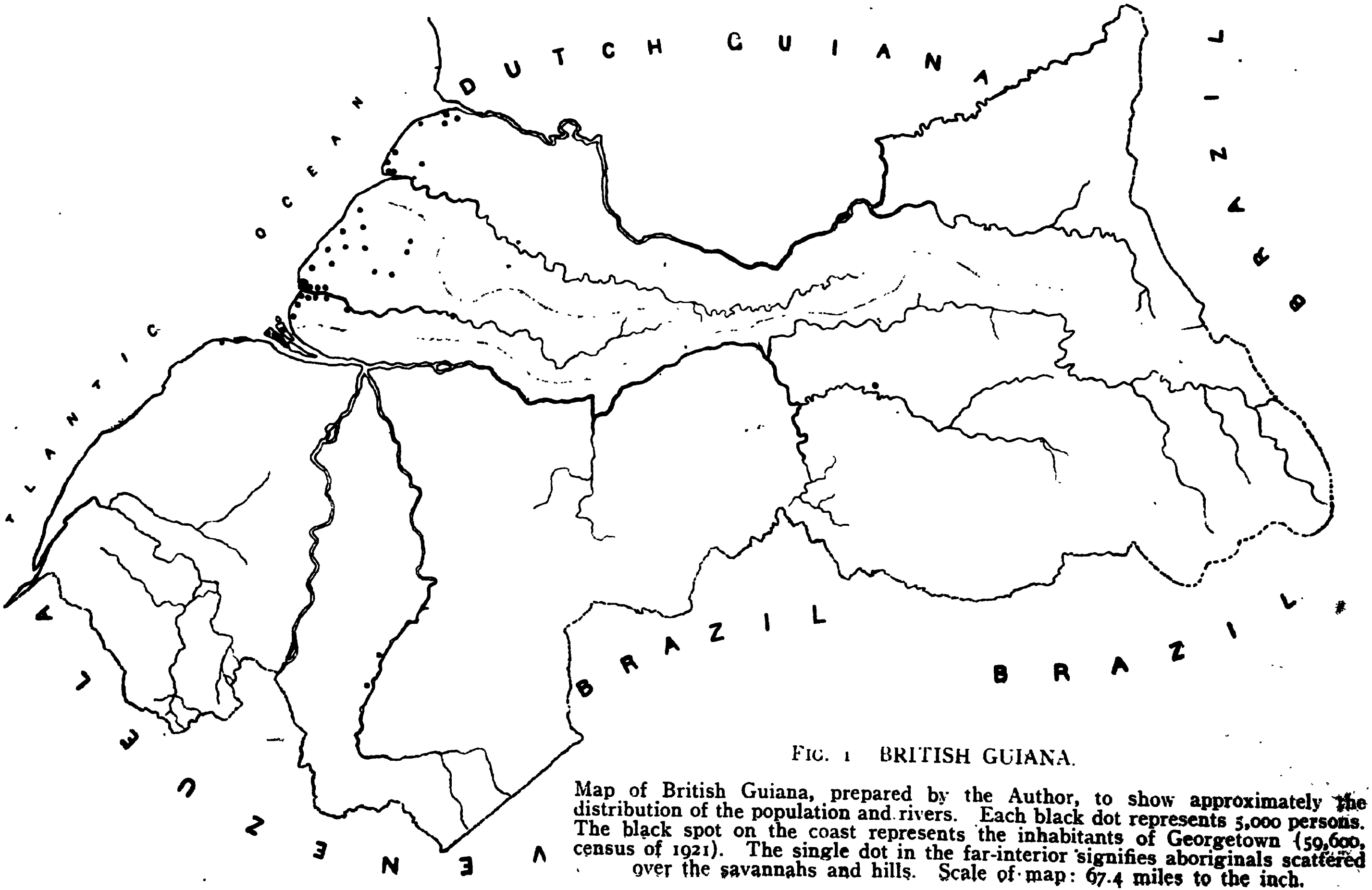

FIG. 1 BRITISH GUIANA.

Map of British Guiana, prepared by the Author, to show approximately the distribution of the population and rivers. Each black dot represents 5,000 persons. The black spot on the coast represents the inhabitants of Georgetown (59,600, census of 1921). The single dot in the far-interior signifies aboriginals scattered over the savannahs and hills. Scale of map: 67.4 miles to the inch.

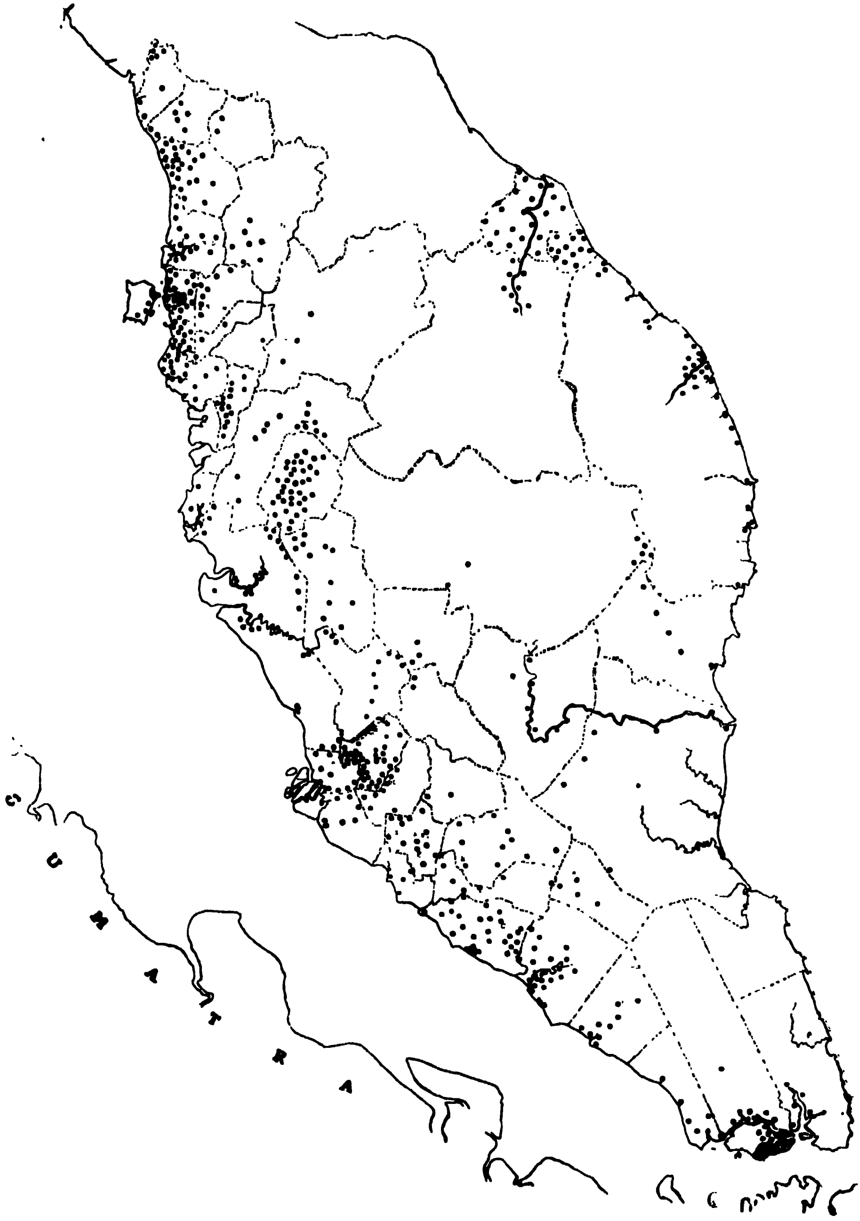

FIG. 2. BRITISH MALAYA.

Map of British Malaya, prepared by the Author, to show approximately the distribution of population. Each black dot represents 5,000 persons. The large black spot in the extreme south represents the inhabitants of Singapore (350,400, census of 1921); that on the north-west island the inhabitants of the municipality of Penang (123,100). Scale of map same as previous one: 67.4 miles to the inch.

£78,714,225, while the value of those of British Guiana was £3,757,647; the value of the imports into British Malaya in 1923 was £69,231,635, the value of the imports into British Guiana £2,668,960; thus the total volume of external trade of British Malaya in 1923 was £147,945,860 and the total external trade of British Guiana, £6,426,607. Prices and general conditions were sufficiently normal or at any rate compensatory, I think, during 1923, to render these values fairly comparable and indicative of the present magnitude of each country's commercial and productive activities.

What then, in the geographical sense, is there to account for this enormous difference in development? We have, I think, to return to where we broke off and consider dissimilarities in respect of each country's more fundamental geographical characteristics.

If you will look at the two large sketch-maps of British Guiana and British Malaya, on which each black dot represents 5,000 persons, it will be readily apparent that the two countries differ to an almost astounding extent (as no doubt you will have known or anticipated) in both the total number and distribution of their inhabitants. Roughly, British Malaya has a population of 3⅓ millions, British Guiana a population of only 300,000.

Now assuming, as I think we may, that the inhabitants of each country are profitably and usefully occupied, their numbers (in conjunction with their ability) is a fundamental factor of development. But the fundamental *problem* is the reason for the difference in population. The same thing applies to the factor of invested capital (or savings) in each country.

If you will now glance again at Mercator's projection of the world you will observe that while British Guiana has a coast line of 250 miles it is essentially a continental region, almost surrounded by the vast, but sparsely populated countries of northern South America, and that it lies well away from the world's great trade routes. British Malaya, on the other hand, is a peninsula, which, apart from possessing all the natural advantages of an extensive coast line combined with continental land connexion, actually lies in the heart of the densely populated East, with India on the west, China on the north-east, Java on the south and Siam and Burma on the north. In addition, the southern extremity of the peninsula lies on the main trade route of the East. These geographical dissimilarities are fundamental in explaining the difference in population. Malaya's geographical position has been favourable, not only for an influx of people from Sumatra in ancient times and from China and from India in more recent times, but for that ebb and flow between it and these countries, and for that personal and political contact and connexion which has long existed between it and India and which I regard as so important.

On the other hand it is necessary to observe, in connexion with external capital and trade, that British Guiana is much closer to England and the world-markets than is British Malaya—at least in mileage. The distance from Georgetown to London by steamer is 4,078 miles; from Singapore to London, the distance is 8,386 miles. The distance from Georgetown to New York and Halifax (Canada) is 2,500 miles and 2,788 miles; whereas the distance from Singapore to New York is 10,141 miles. Against this it may be noted that the freight charges per cent. of the values of a ton of produce shipped from Malaya to London is much less than in the case of British Guiana. And again, Singapore's very distance from London and New York is in fact an asset. It is the central world position that counts. As to contact with the Mother Country, in these days of rapid communications mileage is not a serious obstacle in administrative and commercial directions.

But geographical position is not in itself sufficient to attract population and capital. There must be internal resources and internal features which are advantageous, or rather, features that are not seriously disadvantageous. Or else there must be external pressure. Both have operated. The principal resource of Malaya which in the first instance attracted people and has been largely responsible for her development, is tin. It has been tin that has attracted the Chinese and the early development of the country was largely due to these energetic, clever and enterprising people. Unlike gold and diamonds in British Guiana, tin in Malaya has been a relatively permanent (though not less easy) industry. But tin and the Chinese alone, however, could never have made Malaya. Malaya of to-day has been made by British political administration of a high order, by British capital and by British organisation, and more than anything else, perhaps, by the development of an efficient agriculture rendered possible by the pressure of over-population in India.

What has delayed the development of British Guiana in this way? Admittedly tin has been a great resource-factor in Malaya; but plenty of countries without extensive deposits of valuable minerals have developed and even British Guiana shipped £1,033,014 worth of diamonds in 1923. One can only conclude that although, as we have seen, her geographical isolation has been and is a drawback, there must be internal geographical differences between the two countries, and possibly a different psychology inherent in the ruling inhabitants.

Again asking you to look at the maps before you, I will endeavour to show you that British Guiana, unlike Malaya, suffers on account of her rivers and sea and topography. Where, on the British Guiana map the black dots lie along the coastal lands you have a great flat region of heavy soil lying, for the most part, below sea level at high tide. In spite of most of it being well drained by canals considerable areas are flooded in the rainy seasons, and apart from the presence of anophelene mosquitos, the conditions are not favourable to health and comfort. That is only one point. From a purely economic aspect the great disability lies in having to prevent encroachment of the sea, and the expense of building defences has been and continues to be a drain on the limited financial resources of the Colony. Again, at the mouths of the rivers are muddy bars which are responsible for the limited harbour facilities which I have already described. These bars could not be adequately dredged or harbour works constructed except at enormous expense. Lastly, we have to consider the rivers. These, though they be the principal means of internal transport (as the canals are for agriculture on the coastal flats) are not navigable for large craft for more than 60 miles inland and beyond this it is difficult for small craft on account of the dangerous runs and falls. But the main geographical feature of the British Guiana rivers is that they divide the whole country into five more or less water-tight compartments or "inland islands." This is shown fairly clearly on the map. The Government river-steamer services are fundamentally designed to overcome, as cheaply as possible, this geographical disadvantage.

GENERAL CONSIDERATIONS.—I.

So far, I think, we have been able to illustrate the possible political and educational value of broad geographical comparison, and I think you will have seen that the fundamental reasons why British Guiana is less developed than British Malaya are these: firstly and mainly, because she occupies an unfavourable geographical position; secondly, because her mineral resources have not been so lasting and extensive; thirdly, because she suffers from geographical disabilities in respect of the sea, the rivers and topography. There is nothing very technical in these conclusions, but I think they are illuminating and indicate a field for more intensive study throughout the tropical regions of the world.

POPULATION CHARACTERISTICS.

Having considered general geographical similarities and dissimilarities, the kind of research which I am advocating would next give its attention to the relative industrial and administrative efficiency of such people as each country has got in relation to resources and environment.

We should, however, consider the characteristics and condition of the people, apart from industry, first. I propose to do this very briefly and superficially in regard to the peoples of British Malaya and British Guiana. Incidentally this will give us a clue to a question which must be occupying your minds, namely, why has not the population of British Guiana grown of its own accord?

Concerning racial composition, the Malayan population is mainly composed of Malays (natives but not aboriginals) 49 per cent., Indians (from India) 14 per cent., Chinese 35 per cent., and Europeans 0.4 per cent.; that of British Guiana is mainly composed of Indians (from India) 42 per cent., Negros 39 per cent., mixed race 10 per cent., and Europeans (including

Portuguese) 4 per cent. I have not time at my disposal to consider these figures, but they are very important and full of significance.

Now as regards total population, that of Malaya during the decade 1911-21 increased by 25.6 per cent., whereas that of British Guiana, during the same period, increased by only 0.56 per cent. The former increase was largely the result of immigration, but to a considerable extent the outcome of natural increase among the native Malays. The latter increase was due to a slight total increase among the " Mixed race," and possibly to the development of one or two new industrial ventures. The essential point is that for a good many years the population of British Guiana has been practically stationary, if not, at times, declining. This has been due to the fact that the average death rate is very nearly equal to the average birth rate, and to the fact that immigration from India was stopped for political reasons, in 1917. But I would like to emphasise that statistics show that British Malaya is little better than British Guiana in regard to high death rate and the balance between births and deaths, and it will be clear that natural increment of population is a problem common to both regions, and one, of course, which is closely connected with local sanitation, racial susceptibility and geography.

Of considerable economic significance is the difference of tropical populations by age and literacy and languages. Of the total population of British Malaya in 1921, 28 per cent. were under 15 years of age (and therefore relatively non-productive economically); in British Guiana, 32 per cent. were under 15 years of age. The number of children is to some extent affected by disparity between the sexes being pronounced amongst the Chinese of British Malaya, who until recently have left their wives in China. It is affected, of course, by infantile mortality, which is high in both countries. As to literacy and languages, 90 per cent. of the people, even in the towns of Malaya, are unable to speak English and only 50 per cent. are literate in any language. In British Guiana nearly all the people in the towns speak English and 45 per cent. of the total population claim to be able to read and write English. In other words, except for the East Indian element the people of British Guiana are " Europeanised " and are blending. In British Malaya the vast majority are strictly Oriental and to a great extent in a state of racial segregation.

Finally, I must say a few words in regard to political constitution. This is a very potent factor in regard to tropical development and deserves far more deep scientific study than it has received. It should, like most points in this paper, be approached historically if time would permit. It will be sufficient for our purpose to mention that British Malaya, though an economic unit, is a political complex. Its Government is a combination of Crown Colony, Protectorate and Advisory administration, but all is under British suzerainty, and in connexion with the last mentioned administration, British advice is followed by the native rulers. The constitution of British Guiana is different. Although a Colony it is not a Crown Colony or a

Protectorate, for it has a limited franchise and its internal finances and legislation are mainly in the hands of what are called the Court of Policy and Combined Court. In other words, British Malaya is largely administered, both politically and industrially, from London, whereas British Guiana is largely, though not entirely, administered from Georgetown.

RELATIVE INDUSTRIAL EFFICIENCY.

We now come to the consideration of the people's occupations. The principal products of British Malaya at the present time are, in order of the importance of their export values: rubber, tin, copra and spices, and it was the values of these which principally comprised the £78,714,225 which I have already given as the total value of the exports for 1923. In the case of British Guiana the chief products are sugar and its by-products, diamonds balata, rice, and timber, and the values of these similarly comprised the total value of the exports of this country in 1923, which I quoted as £3,757,647. Now in my remarks on relative resources from a general geographical standpoint, I laid a good deal of emphasis on the importance of mineral wealth because of its powerful psychological or attractive characteristics, not because the mineral wealth of the two countries is fundamental in regard to present and future prosperity. Apart from the fact that rubber and sugar take first place in the exports, it will be quite obvious—or it would be if we went into mining and other details—that the mainstay of the two countries must be industry based on agriculture and forestry.

Knowing the nature of the principal industries, our next task is to consider their geographical distribution. This, of course, if we include all occupations, is practically the same thing as considering the distribution of population and resources. Referring again to the sketch-maps you will see that the distribution of the people in both countries is dominantly *coastal*. This is a characteristic feature of tropical human geography, at least in countries where Europeans are settled, and is connected with soil resources, climate and efficiency of transport. In Malaya, the rubber is produced mainly in the middle west, in the Federated States. Coconuts occur all round the coast, but mainly on the west. Rice is produced in the flatter districts of the north-west and north-east, but also in 10 to 20 mile patches all round the country, especially along the rivers. Tin is also widely distributed, but mainly occurs in Perak, Selangor on the west, and in the east in Kuantan. In British Guiana, sugar, rice and coconuts are all produced within the 40 mile wide coastal belt; diamonds are mainly secured along the Mazaruni river in the interior where two dots are seen; timber mostly from within the region of accessible forests, which does not extend more than about 100 miles inland. Balata comes mainly from the far interior and some cattle are raised on the elevated pastoral savannahs of the extreme south-west.

A limited number of people along the coasts of both countries are engaged in fishing. The great commercial centres are, of course, shown by the black "splodges" at Singapore, Penang, and Georgetown in British Guiana. It cannot be effectively demonstrated on the maps, but it should be noted that the black splodge at the port of Singapore represents as many people as there are in the whole country of British Guiana.

A large amount of work remains to be done in regard to correlations in these industrial distributions, but the field of research which I want to emphasise particularly is the study of the relative efficiency of the industries themselves. This involves economic measurement and investigation designed to enable us to make suggestions for improvement *which do not involve any considerable increase in capital expenditure.* The measurement, which is the first procedure, would involve the determination of (a) costs of production on a standardised and statistical basis, (b) costs per cent. of capital invested, (c) labour employed per unit of output of produce, (d) cost of living, and other matters as might be required. The investigation of efficiency would also be concerned with labour efficiency and efficiency of management on the lines of the well-known work in industrial psychology and physiology of Europe and America. Our aim would be economy of labour with increased output and less fatigue.* We need to understand more about the so-called tropical laziness; and whether, for intance, the labourers of British Malaya are individually and collectively more energetic and willing or less so than those of British Guiana. This is a very important factor in development and industrial efficiency and has never been measured, as it could be, in the tropics.

These are technical matters and it would be quite out of place for me to attempt to discuss methods and details. The central idea which I would like you to keep in mind is economics on a geographical basis. The fundamental idea is *regional.* In the first part of this paper we considered development from the standpoint of each country as a *whole* and in relation to the broadest factors of environment. We are now narrowing down into industrial or occupational regions and we can, if we please, narrow down to such an extent that our fundamental region of investigation is a single agricultural estate or mine. In Trinidad, in the West Indies, I have measured costs (with proper apportionments) even for individual fields. But we must never be parochial, never lose sight of national aspects and world aspects.

The principal world aspect of the industries of British Malaya and British Guiana is that the output of rubber and tin from the former country is, in each case, a predominant part of the world output; whereas the output of sugar from British Guiana is only an infinitesimal part of the world's sugar supply. Except for the supply of green heart timber and perhaps balata, the world would not be inconvenienced if British Guiana entirely disappeared; but if British Malaya suddenly disappeared hundreds of world industries would be absolutely dislocated.

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* The results of some experiments by the writer on this subject are being published in the *Journal of the National Institute of Industrial Psychology.*

I have selected a few figures and statements to illustrate to you what I mean by the measurement of cost-efficiency in these two countries. But the point is, that although they are significant up to a point, they are not absolutely scientific from the standpoint of mathematical statistics and cost accountancy.

During 1922-23 the average "all-in" cost of rubber in Malaya was calculated to be 8.3d. per lb. This compared with pre-war costs indicates a very high standard of efficiency, but it is not as high as the efficiency in Ceylon, where, during the same year, the average cost was 7.92d. per lb. To quote Maclaren (Resources of the Empire Series) " Ceylon as a whole enjoys lower costs of production than any other rubber growing country without exception." As regards sugar in British Guiana I have been given figures which show that the f.o.b. cost per ton is considerably higher than in Cuba (figures for which have been published by the United States Tariff Commission). The inefficiency in British Guiana is not due to inefficient factories for the manufacture of sugar, but to a low output of sugar per acre and the high rate of wages obtaining (2/6 to over 4/- per day, compared with less than 1/- per day in Malaya). It is claimed that sugar does not pay in British Guiana at present market prices. Coming now to the mining industries, the cost of returning clean tin ore in Malaya on mines efficiently equipped is probably between £30 and £60 a ton, and must obviously leave a wide margin with tin at £200 a ton; and although this is too vague to enable us to measure efficiency exactly, the range is wider than in Nigeria, where tin is also produced in large quantities. The cost of producing diamonds in British Guiana I do not know. It is an individualistic, adventurous occupation mainly in the hands of negros. But it is instructive to divide the total value of the exports in 1923 by 10,000 (roughly the number of people employed). This gives an output of only £103 worth of diamonds per head, which I think proves either that not all of the prospectors are making much money or that some of the diamonds are not being declared to the Government before shipment.

Let us next consider the labour employed per unit output in British Malaya and British Guiana. In Malaya, to produce 100 tons of rubber it takes, on an average, about 250 labourers; to produce 100 tons of tin, 240 labourers; to produce 100 tons of rice, 170 labourers. In British Guiana to produce 100 tons of sugar takes only 33 labourers. But when we calculate the value of the output per man we find less variation. With rubber at 1/3 per lb., the value per head in Malaya is £60, and with sugar at £18 per ton, the value per head in British Guiana is £55.

A most important economic question in the tropics is local food production. As a general rule the more developed countries, although agricultural, import most of their food supply. Rice is the fundamental commodity and in regard to the production of rice British Guiana not only excels over British Malaya in output per head of population, but also in yield per acre. I regard the rice industry of British Guiana as a great achievement and it is likely to be the telling factor in any kind of immigration or settlement scheme of the future.

We may conclude this section with a few brief remarks concerning transport and commerce. Obviously from what I have already said concerning road and railways, transport is very efficient in British Malaya and, except for the canal transport of sugar-cane, very inefficient in British Guiana. River freight rates for supplies to the British Guiana diamond fields from Georgetown range around £33 per ton. The journey takes about 3 weeks and the direct geographical distance is only about 150 miles. Compare this with ¾d. per ton per mile for freight on the Malayan railways and with the freight rate for a ton of sugar from Georgetown to London, which in 1923 was 25/- to 27/6 per ton for a journey occupying only 17 days. But in regard to ocean freight generally the rates are high in both countries and in some respects anomalous.

From the point of view of this paper the chief importance of transport is the fact that it is a factor in cost of production and the same applies to commercial activities and services involving commission charges. Commodities, in their economic journey from the point of production to the point of consumption, both inwards and outwards, get their costs increased accumulatively. This is essentially geographical because we are really concerned with distribution, which, to my mind, is even more important in the world to-day than production. But in the sense of world supply and demand, distribution is really a question for the academic economist and statistician. Closely connected with it is that important study—the study of markets and marketing, which does come within the range of this paper, but cannot be dealt with on account of the limited time at our disposal.

GENERAL CONSIDERATIONS.—II.

In regard to industrial efficiency I have endeavoured to indicate the need for the geographical study of distributions and costs and the specialised study of labour economy. Concerning the relative industrial and commercial efficiency of British Guiana and British Malaya it has been shown, I think, that the standard, on the whole, is higher in Malaya. We must not, however, be carried away by the vast difference in the value of the total trade of each country. As I pointed out at the beginning of this paper, there is all the difference between the total national wealth and the wealth per head of each country's inhabitants. You cannot even measure prosperity by money at all, under some tropical conditions. Certainly the average inhabitant of British Guiana is better off financially, I think, than the average inhabitant of Malaya, but I doubt whether he is in all that goes to constitute prosperity and welfare. Our great concern, our great motive in studying industrial efficiency is to assist existing populations to get more out of what they already possess, and I think that this is a line to take in British Guiana, because it would automatically lead to expansion.

EFFICIENCY IN ADMINISTRATION.

Government plays a very active part in tropical development; and, therefore, efficiency in public administration is an economic study. Taking a general view, I think that apart from finance and communication and transport, the principal considerations affecting tropical development are Government policies connected with (a) land administration, (b) forestry, (c) public health, (d) scientific research. Sound policy in regard to land administration is fundamental and a study of the history and present conditions of land tenure in the different tropical countries would well repay the labour involved. The accepted principle now, I think, is that the land belongs to the people, that while land may be alienated in perpetuity it must pay rent to the State and this rent must be periodically revised on the basis of extrinsic improvements like roads. It must also be subject to conditions in regard to efficient utilisation and the State must reserve certain rights in regard to mineral wealth and public works. The periodical rent revision is an essential point and it is worthy of note that while this is provided for in British Malaya it is not provided for in British Guiana.

Connected with land administration and underlying it is Ordnance Survey. Tropical countries differ widely in respect of Survey developments, and you will note on the sketch-maps that while most of the States of Malaya are divided into districts, British Guiana has practically no demarcations in this respect. Another important point is the relatively small size of the Malayan districts; they are much smaller than the districts of India. This encourages efficient district administration.

Colonial economic policy in regard to forestry is also important. On it depends the conservation of vast resources, increased production at reduced costs, and protection from soil denudation. For years British Malaya has had an efficient Forest Service and the reserves in the interior of the country are extensive and scientifically administered. It is only recently, within the last year, that British Guiana has established a proper Forest Service, in spite of timber and balata having been important but gradually receding sources of wealth for many years.

It is scarcely necessary for me to say much concerning public health. I have referred to this subject, at any rate indirectly, so often in the course of this paper. It is clearly fundamental in economic development in the tropics and the great work that has been done in Malaya may best be studied in Dr. Malcolm Watson's book, " The Prevention of Malaria in the Federated Malay States."

Regarding scientific research, by which I mean specialised research in the natural sciences, it is evident that this is also fundamental nowadays for disclosing and measuring resources, in overcoming natural difficulties and obstacles and for bringing to light fresh facts and principles not merely of regional but of universal interest and importance. It is in connexion with agriculture and public health that scientific research finds its greatest fields of economic importance in the tropics and in regard to the former, at any rate, British Malaya, and in relation to her financial resources, British Guiana, are admirably cared for and progressive.

CONCLUSION.

In preparing this paper I have been, all through, face to face with a very serious difficulty, namely, that of keeping the side and main issues perfectly clear and distinct. The side issue is the difference between economic conditions in the two countries I have dealt with, and the problems and questions arising from our analysis. The main issue is the point of view, the philosophy and the nature of the kind of research I am advocating. I feel I have not been very convincing as to the capacity of this research to find out anything really new and practically useful. You may think it is interesting merely from an administrative point of view. You must believe me when I say that I have intentionally kept to generalities and contented myself with easy spectacular illustrations as is appropriate with a non-technical audience. This is no place to discuss rainfall correlations, or the statistical measurement of the relationship between race and thrift, or the apportionment of general charges on a rubber estate. In any case, I can assure you that in this country and in the Empire, economic research such as I have so sketchily illustrated in this paper is at any rate new. It is only just starting in the United States of America, where they are beginning to analyse not only their own territories but ours, more or less from the points of view in this paper. I maintain that a systematic study of the British tropics along the lines suggested, and deep in places, would not only assist in economic development, but would intellectually increase our world prestige. cost very little, and lead in the end to a much better understanding and closer sympathy as even this paper may in regard to the colonisation of British Guiana.

I have to add that I could not have given many of the details in this paper but for the whole-hearted assistance rendered me by the Malay Government Agency, by the Government Trade Commissioner for British Guiana in London, and the Imperial Institute, to whom I tender my thanks.

(At the conclusion of the reading of the paper, the Chair was vacated by Sir Halford Mackinder and taken for the remainder of the meeting by Colonel Sir Charles E. Yate, Bt., C.S.I., C.M.G.)

DISCUSSION.

THE HON. W. ORMSBY-GORE, M.P. (Under Secretary of State for the Colonies), in opening the discussion, said the author had given a most valuable and suggestive line of thought on what he had described as his main point, namely, that very little had been done in the British Empire in the direction indicated, which was, unfortunately, true. He had just been reading a report, not yet published, by Dr. Shantz, of the Department of Agriculture in Washington, on the territories which he (the speaker) had just been visiting, namely, the British territories in East Africa, which showed an extraordinary power of trained observation very much on the lines suggested in the paper, *i.e.*, an attempt to take the historical and the sociological background into consideration on purely agricultural problems. Nothing could be of more value in teaching, not merely those engaged in administration, but those engaged in commerce, all the factors which had to be faced in a comparative study of that kind, in an attempt to get the economic survey away from a narrow view of economics on to a much wider plane. The last time he attended a meeting of the Royal Society of Arts was when he took the Chair for the former Minister of the Belgian Colonies, who read a paper on "Recent Developments in the Congo." The burden of that paper was population and transportation, and those were the two great factors in all economic progress. He could not help thinking, in listening to Mr. Dunlop's paper, that those were the two factors which were more than anything else the reason for the contrast between British Malaya and British Guiana. The trouble was that in both cases the Biblical maxim was true, "To him that hath shall be given," *i.e.*, if a country had population it tended to attract more population and if it was on a great transport route of the world all the subsidiary transport services went there also. The trouble with British Guiana was that, starting with practically no aboriginal population, then having a negro slave population for some time until emancipation, and since then indentured labour from China and India, it had not yet possessed the natural magnet which attracted the free flow of population for the development of great resources. Further, although there were almost exact similarities of latitude and rainfall and very similar soil conditions in the two countries the fact must be recognised that British Guiana was in a part of the world which had so far baffled humanity. But it did not stand alone. It was not as if British Guiana was the one undeveloped part of a rich area of the world. It was, as a matter of fact, he believed, almost the most developed area of all the vast territory lying between the Orinoco and the Amazon. It was a curious fact, too, that practically the foundation of the rubber industry was in that part of the country. Para rubber came from the Amazon basin, but its successful cultivation and economic development had taken place, not in tropical South America, where it naturally flourished to the best advantage, but as an entirely imported, extraneous, non-indigenous product in British Malaya and Ceylon. The first fact to be considered, as he had said, was population, but there was no South American population to go to British Guiana. British Guiana, which was wholly tropical in character, was never going to be prosperously developed, except by a tropical race. Indian immigration was the most hopeful, because Indian people had been the most successful in British Guiana, but if the undertaking was to be successful the Indians must be very largely Indians from Southern India. It was in the gradual development of the Indian rice cultivator and the Indian farmer settler that the best chance lay of the development of British Guiana. With regard to transportation, the mere fact that large steamers could not enter the ports of British Guiana set that country at a geographical disadvantage in the modern world. He had seen something, during his recent tour, of the terrific handicap to development of inadequate harbour facilities along the Coast of Africa, where it was only a question of expenditure of money to make them quite first class; and in the modern world competition for raw materials the establishment of adequate harbour facilities was of prime importance. With regard to railways some people were apt to think that it was only necessary to put a railway down and then, as in the case of the Canadian Pacific, everybody would be happy ever-afterwards. That was a great fallacy. It was absolutely essential, before embarking upon railway transport, which was very expensive to construct, particularly in a wet country like British Guiana, to be exceedingly careful. Various suggestions had been made from time to time as to how a commencement should be made to develop a country like British Guiana, and the more he thought it over the more he was convinced that it would never be developed except in two ways, firstly, the very slow development of India settlers pegging away at agriculture, gradually clearing and taking up the land that was lying waste for anybody to have at the present moment, and growing the excellent crops which could be grown there; and, secondly, something in the nature of a big development company. It was a psychological fact, however, that a big development company could not be formed in countries of that kind unless minerals were present. That had been the case in Rhodesia and Malaya, which, through their minerals, had attracted British capital. British Guiana probably had big mineral resources, although nobody knew where they were or what they were at present; but sooner or later somebody would find mineral resources in that country, and then there would probably be a rush of population and capital. Similarly the question of the discovery of cheaper and more efficient transportation in the tropics was a problem which was worthy of the most serious consideration. People laughed at roadrails and other new ideas, but every one of them ought to be examined on its merits in case something turned up which would prevent a setback to all schemes of development, which came from the great difficulty of getting public or private capital to open up new countries with transport facilities unless they were absolutely assured of how many tons a year they would be able to carry and whether the debentures would be able to earn their interest. The paper was of particular value to him, and in the paper on East Africa that he would have the honour of reading before the Society later in the year, he should pursue in several cases exactly the line of thought which the author had opened up.

Sir Wilfred Collet, K.C.M.G., LL.B. (late Governor of British Guiana) said that in the immigration system which was adopted in connexion with British Guiana it was agreed with every immigrant that if he wanted to go home again he should be sent back by the Government. That, of course, was not the way to keep a population. The Indians who were able to find wives settled in the colony, which was much healthier than was generally thought. If there were a lot of single men in the colony who died without children the death rate was naturally large; but, as a matter of fact, the death rate of the colony was not nearly as bad as people imagined. If the number of East Indians born in the colony in 1911 was compared with the number born in 1921, it would be found, according to the census returns, that the increase was 27 per cent. The colony had recently been obliged to send Indians back to India, and had not been allowed to bring Indians in, which had had an unfavourable effect on the census returns. A number of those, however, who were sent back returned to the colony at their own expense. There was a very large population in India, many millions of whom were probably better off than the Indians in British Guiana, but he had seen the Indians who came to that colony, and knew that their descendants were a very much finer race of men than their ancestors, and were doing very much better than they could possibly have done in their own country. The introduction to British Guiana of immigrants of that class was, therefore, not only of benefit to the colony, but to the immigrants themselves, while it was also of benefit to the over-populated parts of India, Immigration of that class ought to be encouraged; if it was not, the colony would have to get on without such help, and its progress to a certain extent would be slow. There was very little opportunity of obtaining population from the British West Indies, because there was not sufficient population in the West Indies themselves. Barbados was the only island which was over-populated. Of course, there would be a considerable increase of population by natural increase, whether there was immigration or not, but there was room for quite 20 million people eventually in the colony. British Guiana was capable not only of great agricultural, but also industrial development. Not only were there minerals in the country, but enormous water-power, which at present was running to waste, because it happened to be at a distance from the coast. He doubted whether any country, except Canada, would be better supplied eventually with water-power from natural sources. But population was urgently necessary, because at the present moment when any new undertaking was begun labourers were taken away from an existing industry to start the new one, with a very disturbing effect. With regard to the present Constitution of British Guiana, if the United Kingdom would take sufficient interest in British Guiana and see that it had the opportunity of bringing in settlers they would either find the Constitution as it worked at present sufficient for the purpose or the people would agree to have it altered. The British planters and their predecessors who founded the colony could not, he thought, be charged with want of enterprise or of grit. Governors who had had to deal with them at times found that they were extremely obstinate, but they were just as obstinate in times of reverse as in times of prosperity. It did not matter how bad things were, the settlers stuck to their work and pulled through, as they had done quite recently.

MR. H. HAMEL SMITH, in speaking on the question of attracting settlers to a country, said that in a book he once wrote on the rubber industry of the Amazon, he informed the Brazilians that unless Japanese, Chinese or other immigrants were introduced, not only into the Amazon region, but the semi-arid regions, from which they were drawing labourers, to tap the trees, not only would the population never increase, but they would find it decreasing year by year. He could not help feeling that, if any good was ever to be done in British Guiana, some nucleus of colonisation on the same lines must be obtained. In another book he wrote on coconuts, Lord Leverhulme in the preface called attention to what had been done by the railways in Canada in establishing settlements, putting up houses and fences and leaving areas between the houses for future use. Lord Leverhulme claimed that where that had been done no money had been lost to the companies. The people when they came out to the colony had a home to go into, and they immediately started earning money by building homes for other immigrants. If the supply was not equal to the demand it was, of course, necessary to build more houses. In the case of British Guiana, the trouble was which race of people were to be put into the houses, and he still favoured the Chinese or the Japanese for the purpose, because China and Japan had a surplus population. If more Indians were introduced into British Guiana trouble would ensue, because with every anna rise in wages in India there was an outcry against the population being allowed to emigrate. The Chinese were very good gardeners, very quiet in their habits, and they could be used to do the spade work in a rather difficult situation. If that were done other people might be induced to immigrate to the country. The great difficulty was that it was necessary to have tropical people to develop the tropics, and there was not sufficient anywhere to move from one part of the tropics to another. That was the chief reason why he strongly advocated that attention should be turned to the over-populated countries of Japan and China, with the object of opening up British Guiana and establishing homesteads.

When his father first went to British Guiana there were some very good establishments founded by the Jesuits right away in the forest, and they became self-supporting. He thought at a pinch a start might be made on that basis; if that was not done he did not think British Guiana would ever develop until, as Mr. Ormsby-Gore said, a lucky prospector found some minerals in the country.

THE CHAIRMAN (SIR CHARLES YATE) said it was news to him that British Guiana, although a British Colony, was not a Crown Colony or Protectorate, and that its internal finances and legislation were mainly in the hands of what were called the Court of Policy and Combined Court. He did not know what a Court of Policy meant in the British Constitution. Personally, he would prefer to see British Guiana a Crown Colony and administered from London, just as British Malaya was. So far as could be judged from the paper and the discussion, the administration at Georgetown had not produced very great results, much being wanting in many ways. He supposed the Constitution had been inherited from the Dutch, but whether it could be altered or not he did not know. It looked, however, as if it required a little "gingering up," and he hoped something would be done in that direction before long. He trusted that, as a result of the reading of Mr. Dunlop's paper, British Guiana would receive more attention from the British public. He had been astonished at the enormous cost of the freight from Georgetown to England, and could not understand the great difference in that cost as compared with Malaya, which was double the distance from England. Probably the want of harbour accommodation militated against British Guiana in that respect. He noticed that the relative size of the Malayan districts was much smaller than those in India. In his opinion, the districts in India were far too large, and he had advocated that the Governorships should be immediately reduced by at least one half. He was entirely in favour of Lord Curzon's preference for Chief Commissionerships rather than Lieutenant-Governorships. When a Legislative Council had a population of 50 million people to deal with, he did not think any Eastern Council that had yet been established was capable of administering the Province satisfactorily. There was evidently need for the establishment of a Forest Service in British Guiana. India had established one of the best Forest Services in the world. He hoped British Guiana would be able to obtain the loan of some of India's highly-trained officers. With regard to the future population of British Guiana, as the author stated, the immigration of Indians was stopped in 1917, and there had been a good deal of agitation in India about indentured labour leaving the country. Mr. Hamel Smith had advocated the introduction of Chinese and Japanese. But it must be remembered that many parts of China and Japan were cold, and he did not know whether the inhabitants from those districts would be fitted for work in the tropics. Personally, he hoped the ban on Indian immigration would be removed, not that India had a much greater population than it required for itself, because labour was getting scarce in India, but a great many Indians had gone to British Guiana, had established themselves there, and made high positions for themselves, and others he hoped would do the same.

DR. J. AUGUSTUS VOELCKER, in proposing a vote of thanks to the author for his valuable paper, thought Mr. Dunlop had made out a complete case for the study of economics in this relation, and he had, moreover, shown the right way in which economic proposals should be taken up. He was sure there was a desire on the part of many people that economists should go further still and give their opinions in respect of the causes of the great differences that were found in different colonies. While the paper was being read, he had endeavoured to come to a conclusion in regard to the real causes of the wide differences between Malaya and British Guiana. Was it due to the fact that the more British there were in a place the worse it was; was it due to the political conditions; was it due to the fact that wages were higher, or to the defects of distribution, or because the people of British Guiana were lazier than those in Malaya? Although the author was an economist, he did not give the audience very much guidance as to what was the primary cause of the difference. The Under Secretary of State had gone a good deal further and hinted at some very clear causes, but whether all would agree with him was another matter. One conclusion they could not help drawing was that the less Government had to do with a colony the better. Mr. Ormsby-Gore observed that there were two main remedies, the influx of population from India, and the finding of minerals, his contention being that if a country did not contain minerals it was not a bit of good. Personally, he was not prepared to accept that statement, more particularly in view of the enormous riches that had been produced from the development of rubber, coffee and many other agricultural industries. This had taken place in countries in which minerals had not been discovered at all. He could quite understand that American speculators would not put their money into agriculture; no wise man did that nowadays, unless there was a chance of "black diamonds" being found, but, personally, he was loath to believe that the existence of minerals was of itself a necessity for the prosperity of a country. Every one welcomed the growing interest that was now being taken in the colonies. The Royal Society of Arts had not been backward in fostering that spirit, and several papers had been read at its meetings, urging that greater attention should be paid to the resources of the Empire. The Exhibition at Wembley had brought home to the people of this country the possibilities of our oversea possessions, including British Guiana, and it was now only necessary to get the economist to decide the causes of the non-development of particular areas and then get the capitalist to supply the money. He pleaded for the necessity of greater scientific attention being directed to the points involved. It had been made quite clear in regard to agriculture that there could be a considerable increase in the outturn of sugar by the adoption of better methods and the growth of better varieties, and the same remark applied to many agricultural industries, such as rubber. He hoped greater enthusiasm would be exhibited on the part of the people of this country in regard to the colonies, and the paper that Mr. Dunlop had read would, he was sure, lead to that desirable end.

The motion was carried unanimously.

MR. DUNLOP, in replying to the vote of thanks, said Mr. Ormsby-Gore had raised the question why there should be a rubber industry in Malaya and not in British Guiana, which was situated in the Amazon region, the natural home of the Hevea tree. The reason was that in the Amazon region a leaf disease existed which was one factor in preventing the cultivation of rubber, even if labour existed. At present that disease had not reached the Federated Malay States, due to the fact that the spore lost its vitality in travelling across the Atlantic; but if any one carried a culture of the spore from British Guiana to Malaya it might cause the destruction of millions of pounds worth of British capital and ruin the rubber industry. There were also scientific explanations for other points raised by Mr. Ormsby-Gore. Dr. Voelcker had stated that the paper did not explain the causes of the differences mentioned. He (Mr. Dunlop) thought it did to some extent, but in any case the paper was chiefly written from the point of view of suggesting lines of investigation, and not primarily to solve the great problems connected with British Guiana.

PROFESSOR LILIAN KNOWLES, Litt.D., writes :—There is no doubt whatever as to the importance of the British Tropics in the economy of the world to-day. In an age which travels on rubber tyres and walks on rubber heels : which is largely dependent for its supplies of soaps, candles, margarine, paints and lubricants on palm oil, copra and tropical oil seeds ; which consumes cocoa in increasing quantities, either as a drink " grateful and comforting," or in enormous quantities as chocolates ; in which much of our wheat reaches us in gunny bags made from jute ; in which our linoleum and some of our carpets and rugs are also packed with or made of jute ; in which sugar and tobacco are in increasing demand all over the world ; in which binder twine, used wherever agricultural machinery is employed, is made from sisal hemp ; in which there is a threatened famine in raw cotton ; and in which tropical and sub-tropical fruits and such universal stimulants as tea and coffee come from the tropics or sub-tropics, there can be no two opinions as to the overwhelming importance of the study of tropical economic problems. The tropics are, however, not merely important as yielding indispensable commodities, but if they can sell they can buy, and they afford growing markets for engineering and textile production of all kinds. Railway equipment, harbour equipment, drains and water pipes are all part of the return payment Great Britain makes for tropical products. As the native inhabitants of the tropics increase in wealth they demand more cloth, scented soap, bicycles and even motor cars. I have little doubt that the nation which controls the tropics will in the twentieth century control the most important raw materials and the growing markets of the world.

An attempt was made to relieve the depression in England caused by the Napoleonic Wars by abolishing the trading monopoly of the East India Company in 1813, and so opening the trade with India. Since the war of 1914-18 a similar attempt is being made to develop the British Tropics to relieve the after-war depression. It is important that this should proceed on right lines. Thus, at the moment, there is a special urgency to consider the possibilities of our tropical possessions, and Mr. Dunlop, in his paper, has shown us one valuable method of approaching the question. The natural capital with which a country starts out in its rivers, climate, soil and general situation is one thing, the human material which utilises the natural capital—or which does not use it—the organisation of the marketing of the produce, the creation of transport facilities, the capital and credit obtainable—these are vital questions which have hitherto been too much obscured by the scientists on the one hand, with their brilliant discoveries, and by the lawyers, on the other, with their absorption in forms of government. It is the academic economists and the historians who ought now to make their contribution by thinking out a policy of development, based on a co-ordinated knowledge of geography, history, economics, administration and psychology. To this Mr. Dunlop has contributed valuable suggestions in his paper.

The interesting question why British Guiana is relatively unprogressive and Malaya so go-ahead does not, in my opinion, resolve itself merely into a question of geography. The economic historian realises what a large part history also plays in determining the psychology of the development of the British Tropics. For instance, the direction of the development of the Federated Malay States and Nigeria was largely influenced by two men of genius—Sir Frank Swettenham in Malaya and Sir Frederick Lugard in Nigeria.

Again, British Malaya was influenced by the general course of economic development in India. The first British settlements in Malaya were made by the East India Company, who wanted ports for shelter and refitting on the way to China, and so occupied Penang and Singapore. To that extent it is a question of geography. But as the sub-continent of India came more and more under British rule, the question resolved itself into one of communications to hold India by moving troops rapidly, and that led to the building of railways, especially after the Mutiny. Malaya was no longer governed from India after 1874, but the tradition of railways was inherited, and the Federated Malay States have been largely created by their railway net, built out of the surplus revenue obtained by an export duty on tin. On the other hand, British Guiana, with its intimate connexion with the West Indian islands, had a sea tradition, not a land tradition, as in India, and steamers, canals and water traffic are as natural a development for her as railways in Malaya. Railways attract a large body of labourers to make them, they are the great technical training ground of native peoples, both in constructing and operating them, and in the repairing shops they offer an alternative occupation to agriculturists, and like mines they are an excellent market for local produce during construction. They not merely open up a country, they create a new atmosphere, an industrial tradition and promote a more rapid turnover. This special stimulus has been absent in British Guiana. Some of the British Tropics have never had the great asset which Malaya enjoyed in the tin which attracted the Chinese—yet they have prospered. Ceylon, Nigeria, the Gold Coast, Jamaica, North Borneo, Uganda, and the flourishing Dutch Colonies of Sumatra and Java have owed little to minerals. Only Rhodesia and Malaya started on a mineral basis. In the temperate regions the Dominion of Canada is an example of a country that became great on fish, furs, wheat, dairying and lumber. Her mineral era is just beginning. Mr. Dunlop makes us think when he sets us the concrete problem, Why is Malaya more prosperous than British Guiana ? In an age when man is dominant over nature, when capital, engineering and scientific knowledge are available, when human beings are triumphing over the barriers of space and distance, when men are " making over " tropical agriculture and helping to conquer insect pests, it is easy to do something when we know what to do. This is a practical age. Mr. Dunlop has indicated one method of finding out the reasons for retarded development, and this will go some way towards altering the conditions which hinder advance.

MEETINGS OF THE SOCIETY TO MARCH 25, 1925.

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ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock, unless otherwise announced :—

FEBRUARY 25.—SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., "The Power of Internal Combustion Engines for Motor Cars." THE HON. SIR CHARLES A. PARSONS, K.C.B., LL.D., D.Sc., F.R.S., will preside.

MARCH 4.—PROFESSOR W. E. S. TURNER, O.B.E., D.Sc., F.Inst.P., Department of Glass Technology, University of Sheffield, "The Modern Production of Sheet-Glass."

MARCH 11. (4.30 p.m.)—EMILE CAMMAERTS, "The Restoration of Public Buildings in Belgium." VISCOUNT BURNHAM, C.H., LL.D., will preside.

MARCH 18.—CLAUDE N. FRIESE-GREENE, "Colour Cinematography,"

MARCH 25.—HENRY G. DOWLING, " Wall-papers."

INDIAN SECTION.

Friday afternoon, at 4.30 o'clock :—

MARCH 6.—SIR HENRY SHARP, C.S.I., C.I.E., M.A., "The Development of Indian Universities." THE RT. HON. VISCOUNT CHELMSFORD, G.C.S.I., G.C.M.G., G.C.I.E., G.B.E., will preside.

DOMINIONS AND COLONIES SECTION.

Tuesday afternoon, at 4.30 o'clock :—

FEBRUARY 24.—R. H. BRACKENBURY, Member of the Empire Cotton Growing Corporation Mechanical Transport Sub-Committee, " Transport in Tropical Africa." MAJOR-GENERAL SIR ERNEST D. SWINTON, K.B.E., C.B., D.S.O., R.E., will preside.

CANTOR LECTURES.

Monday evenings, at 8 o'clock :—

WALTER ROSENHAIN, D.Sc., F.R.S., Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory " The Inner Structure of Alloys."

SYLLABUS.

LECTURE II.—FEBRUARY 23.—Nature of Solid Solutions. Possible Arrangement of Atoms. Proof of the Substitution Hypothesis. Theory of Lattice Distortion. Melting and Freezing. Lattice Expansion, local and general. Lattice Compression and Rise of Melting Point. Strength and Ductility. Lattice Distortion under Stress. Slip and Amorphous Layers. Inter-Crystalline Boundaries.

LECTURE III.—MARCH 2.—Electrical Conduction. Passage of Electrons through Atomic Lattice. Effect of Distortion and Thermal Agitation. Super-Conductivity. Other effects of Distortion. Colours of Alloys. Magnetic Properties. Solid Solutions with no Distortion. Inter-metallic Compounds. Difference from " Symmetrical Solid Solutions." General Bearing on Scientific Metallurgy. Structure of Complex Alloys. Balancing Distortion. Calculation of Equilibria.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, FEBRUARY 23..Geographical Society, 135, New Bond Street, W. 8.30 p.m. Colonel Sir Gerald Lenox-Conyngham and Mr. F. A. Potts, " The Great Barrier Reef."

East India Association, Caxton Hall, Westminster, S.W. 3.30 p.m. Mr. Stanley P. Rice, " India's Gifts to England."

Architectural Association, 34, Bedford Square, W.C. 8 p.m. Messrs. H. M. Robertson and F. R. Yerbury, " The Lessons of Northern Architecture."

Victoria Institute, Central Buildings, Westminster, S.W. 4.30 p.m. Prof. A. T. Clay, " The Amaru."

Victoria League, 22, Eccleston Square, S.W. 5. p.m. Mr. J. B. Cassels, " British Guiana."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 7 p.m. (Informal Meeting). Mr. W. L. Warrilow, " The Electrical Journals, Past, Present and Future."

(N. Eastern Centre) Armstrong College, Newcastle-on-Tyne. 7.15 p.m. Mr. H. W. Clothier, " The Design of Electrical Plant, Control Gear and Connections for Protection against Shock, Fire and Faults."

Swiney Lectures, King's College, Strand, W.C. 5.30 p.m. Dr. W. T. Gordon, " The Geological History of Plants." (Lecture I).

Economics and Political Science, London School of, Houghton Street, Aldwych, W.C. 5 p.m. Mr. E. B. Behrens, " International Problems of Industry." (Lecture VI), " The Future."

University of London, King's College, Strand, W.C. 5 p.m. Dr. J. A. Hewitt, "Carbohydrate Metabolism." (Lecture VI). 5.30 p.m. Dr. R. W. Seton-Watson, " The Origins of the War in its Balkan Aspect." (Lecture II). 5.30 p.m. Rev. C. F. Rogers, " Ecclesiastical Music." (Lecture V).

Actuaries, Institute of, Staple Inn Hall, Holborn, W.C. 5 p.m. Mr. F. L. Collins, " Winding up a Life Assurance Company under the Provisions of Section 17 of the Assurance Companies Act, 1909."

City of London College, White Street, Moorfields, E.C. 5.30 p.m. Mr. C. R. Rottboll, " Commercial Developments in Europe." (Lecture II). " Denmark."

TUESDAY, FEBRUARY 24..Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Mr. L. H. Savile, " The Demolition of the Harbour and Defence Works of Heligoland."

Royal Institution, Albemarle Street, W. 5.15. p.m. Professor J. Barcroft, " The Colour of the Chameleon."

Anthropological Institute, at the London School of Economics, Houghton Street, Aldwych, W.C. 8.15 p.m. Mr. L. H. D. Buxton, "The Stoney Indians of the Bow River, Alberta."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C. 3 p.m. Captain C. E. Hutton, "From the Atlantic to the Pacific."

Photographic Society, 35, Russell Square, W.C. 7 p.m.

1. Mr. K. C. D. Hickman, "Colour and the Psychology of the Kinema."

2. Mr. O. Bloch, "A Daylight Viewing and Projecting Filter for Autochrome Plates."

Electrical Engineers, Institution of, (N. Midland Centre) Hotel Metropole, King Street, Leeds. 7 p.m. Mr. T. D. Trees, "Selection of Ball and Roller Bearings for Electrical Machines."

Automobile Engineers, Institution of, (Informal Meeting) 83, Pall Mall, S.W. 7 p.m. Discussion on "Curious Breakdowns."

(Graduates' Section), Broadgate Café, Coventry. 7.15 p.m. Mr. L. J. Shorter, "The Testing of the Automobile."

Auctioneers' and Estate Agents' Institute, 29, Lincoln's Inn Fields, W.C. 11.30 a.m. Conference of Agricultural Members. 3 p.m. Dr. Crowther, "The Assessment of Residual Manurial Values of Feeding Stuffs and Fertilisers."

University of London, University College, Gower Street, W.C. 5.30 p.m. Mr. N. H. Baynes, "Some Aspects of Byzantine Civilisation." (Lecture IV). 5.30 p.m. Dr. C. F. Sonntag, "Man's Place in Nature."

At King's College, Strand, W.C. 5.30 p.m. Prof. W. G. De Burgh, "Neo-Platonism and Christianity."

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia from 1861." (Lecture VI).

Wednesday, February 25..Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

Prof. A. H. Cox, (a) "The Geology of Cader Idris (Merionethshire)." (b) "The Dissection of Pitching Folds."

United Service Institution, Whitehall, S.W. 3 p.m. Major-General H. F. Thuillier, "Engineers and the Army."

Economics and Political Science, London School of, Houghton Street, Aldwych, W.C. 5 p.m. Mr. C. H. C. Baker, "The Principles of Design as Applied to Our Homes."

Oriental Studies, School of, London Institution, Finsbury Circus, E.C. 5.15 p.m. Mr. E. Richmond, "Early Moslem Architecture." (Lecture III).

Automobile Engineers, Institution of, (N. England Centre), The University, Liverpool. 7 p.m. Mr. C. H. Macmillan, "Marine Motor Installation."

Microscopical Society, 20, Hanover Square, W. 7.30 p.m.

1. Dr. J. A. Murray, "The Making of Microscopical Preparations, (Wet)."

2. Mr. F. Summers, "Applications of the Microscope in Textile Research."

3. Mr. T. B. Bright, "Methods of Examination of Mildewed Cotton Material."

University of London, University College, Gower Street, W.C. 5.30 p.m. Mr. I. C. Gröndahl, "Nature Feeling in Norwegian Literature after Wergeland." (Lecture III).

6 p.m. Mr. H. Higgs, "The Financial Problems of Europe." (Lecture VI).

At King's College, Strand, W.C. 5.30 p.m. Miss I. E. Power, "The Opening of the Land Routes to Cathay, A.D. 1200-1350."

At St. Bartholomew's Hospital Medical School, 6, Giltspur Street, E.C. 5 p.m. Dr. J. M. D. Scott, "The Medullary Centres." (Lecture III).

At the Royal Society of Medicine, 1, Wimpole Street, W. 5 p.m. Prof. R. Cruchet, "The Relation of Paralysis Agitans to the Parkinsonian Syndrome of Epidemic Encephalitis."

Swiney Lectures, King's College, Strand, W.C. 5.30 p.m. Dr. W. T. Gordon, "The Geological History of Plants." (Lecture II).

Thursday, February 26..Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W 8.30 p.m.

Victoria and Albert Museum, South Kensington, S.W. 6 p.m. Mr. W. A. H. King, "Sèvres Porcelain."

Textile Institute (London Section), 38, Bloomsbury Square, W.C. 7 p.m. Mr. J. Howard, "Discrimination between Flax and Hemp, Jute and Cotton, etc."

Chemical Society, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W. 8 p.m. Sir William B. Hardy, "Problems Presented by Films on Solid Surfaces."

Auctioneers' and Estate Agents' Institute, 29, Lincoln's Inn Fields, W.C. (Junior Members' meeting). 7.30 p.m. Series of Mock Rating Appeals.

Royal Institution, Albemarle Street, W. 5.15 p.m. Sir Arthur S. Woodward, "Dinosaurs." (Lecture I).

Automobile Engineers, Institution of, (Luton Graduates' Section), at the Training School, Vauxhall Motors. 7.30 p.m. Mr. W. B. Draper, "The Balancing of Automobile Engine Crankshafts."

University of London, University College, Gower Street, W.C. 5.15 p.m. Prof J. E. G. de Montmorency, "African Customary Law, with special reference to Early Egyptian Law." (Lecture VI).

5 p.m. Dr. A. S. Parkes, "The Physiology of Reproduction." (Lecture VI).

5 p.m. Mr. G. A. Sutherland, "Auditorium Acoustics." (Lecture I).

5.15 p.m. Sir Henry Hadow, "The Place of Music in University Education."

At King's College, Strand, W.C. 5.30 p.m. Dr. E. W. Scripture, "German Poets and their Verse."

5.30 p.m. Dr. A. R. Pastor, "Spanish Saints and Heretics." (Lecture I).

6.30 p.m. Dr. O. Vocadlo, "Czech Civilisation," (Lecture VI).

At the Middlesex Hospital Medical School, Cleveland Street, W. 5 p.m. Mr. E. C. Dodds, "Chemistry of the Internal Secretions." (Lecture VII).

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Prince D. S. Svyatopolk, "Russian Literature in the Second Half of the Nineteenth Century," (Lecture VI).

Mechanical Engineers, Institution of, (Midland Branch), Queen's Hotel, Birmingham. 6.30 p.m. Mr. J. T. Ord, "The Manufacture of Nitrate of Soda in Chile." (Western Branch) at the Merchant Venturers' Technical College, Unity Street, Bristol. 7 p.m. Mr. W. H. Pearce, "The Practical Testing of Locomotives."

Sociological Society, at the Royal Society, Burlington House, Piccadilly, W. 8.15 p.m. Mr. C. B. Fawcett, "The Distribution of Population over the Land."

Friday, February 27..Engineers, Junior Institution of 39, Victoria Street, S.W. 7.30 p.m. Mr. E. Stroud, "A Treatise on Modern Lighting Practice."

Industrial Psychology, National Institute of, 329 High Holborn, W.C. Miss W. Spielman, "Certain Psychological Tests applied to the Selection of Workers in different occupations."

Royal Institution, Albemarle Street, W. 9 p.m. Dr. J. C. Irvine, "Sugars from the Standpoint of the Organic Chemist."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. H. Pickwill, "The Monuments and Fountains of London."

Central Asian Society, 74, Grosvenor Street, S.W. 5 p.m.

University of London, King's College, Strand, W.C. 5.30 p.m. Mr. N. B. Jopson, "The Early History of the Slavs." (Lecture IV).

5.30 p.m. Prof. R. W. Chambers, "The Problem of *Sir Thomas More*." (Shakespeare Association).

Mechanical Engineers, Institution of (Informal Meeting), Storey's Gate, Westminster, S.W. 7 p.m. Discussion on "Practical Problems of Lubrication."

Brewing, Institute of, Brewers' Hall, Addle Street, E.C. 4.30 p.m. Annual General Meeting.

Saturday, February 28..Medici Society at the Royal Society of Arts, John Street, Adelphi, W.C. 3 p.m.

Royal Institution, Albemarle Street, W. 3 p.m. Prof. Sir Ernest Rutherford, "The Counting of the Atoms." (Lecture I).

London County Council, at the Horniman, Museum Forest Hill, S.E. 3.30 p.m. Mr. W. J. Perry, "The Ancient Mariners of the Pacific"

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FRIDAY, FEBRUARY 27, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 2nd, at 8 p.m. (Cantor Lecture.) WALTER ROSENHAIN, D.SC., F.R.S., Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory, " The Inner Structure of Alloys." (Lecture III.)

WEDNESDAY, MARCH 4th, at 8 p.m. (Ordinary Meeting.) PROFESSOR W. E. S. TURNER, O.B.E., D.SC., F.INST.P., Department of Glass Technology, University of Sheffield, " The Modern Production of Sheet-Glass."

FRIDAY, MARCH 6th, at 4.30 p.m. (Indian Section.) SIR HENRY SHARP, C.S.I., M.A., " The Development of Indian Universities." THE RT. HON. VISCOUNT CHELMSFORD, G.C.S.I., G.C.M.G., G.C.I.E., G.B.E., will preside. Tea and coffee will be served in the Library at 3.45 p.m.

CANTOR LECTURE.

MONDAY EVENING, FEBRUARY 23rd, 1925, DR. WALTER ROSENHAIN, D.SC., F.R.S., Superintendent, Department of Metallurgy and Metallurgical Chemistry, National Physical Laboratory, delivered the second lecture of his course on " The Inner Structure of Alloys."

The lectures will be published in the *Journal* during the Summer recess.

ELEVENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 18th, 1925. SIR NAPIER SHAW, LL.D., Sc.D., F.R.S., in the Chair.

The following Candidates were proposed for election as Fellows of the Society:—

Burns, Alan Chamley, M.Sc., F.I.C., Whitehaven, Cumberland.
Cohen, George, London.

Cooksley, Allan, Birmingham.
Dow, Alexander, London.
Dunhill, Alfred, Harrow Weald, Middlesex.
Henry, William Ethelbert, Maidenhead, Berks.
Hirniak, Dr. Julian, Lwow, Poland.
Howatson, Lieut. G. A. S., I.M.D., Almora, India.
Jessop, Arthur, Rawdon, Leeds.
Marsden, Andrew, M.I.Mar.E., Gravesend, Kent.
Rowe, Harold Charles, J.P., Exeter.
Sadhu, Pandit Tara Chand, Srinagar, Kashmir, India.
Simmonds, Ernest John, Gerrard's Cross, Bucks.
Yates, Charles, Hailey Hall, near Hertford.

The following Candidates were duly elected Fellows of the Society :—

Andrews, Gerald Willoughby, London.
Biles, Sir John Harvard, K.C.I.E., LL.D., D.Sc., M.Inst.C.E., London
Cohen, Sir Herbert Benjamin, Bt., O.B.E., London.
Collin, James B., London.
Crow, William Roberts, London.
Daniel, W. John, Trivandrum, India.
Nelson, Horatio Whiteway, Bradford, Yorks.
North, William James, Watford, Herts.

A paper on " Modern Atmospheric Conditions " was read by Dr. J. S. Owens, M.D., Assoc.M.Inst.C.E., F.G.S., Superintendent, Advisory Committee on Atmospheric Pollution, Air Ministry, Meteorological Office.

The following took part in the discussion : —Sir Frank Baines, C.V.O., C.B.E., Director of Works, H.M. Office of Works; Dr. A. W. Hill, F.R.S., Sc.D., F.L.S., Director, Royal Botanic Gardens, Kew; Col. Sir Arthur Holbrook, K.B.E., M.P.; Mr. F. W. Goodenough (Gas Light and Coke Company); and Mrs. M. Fishenden (Fuel Research Board).

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

TENTH ORDINARY MEETING.

Lord Bearsted, LL.D., a Vice-President of the Society, in the Chair.

The Chairman, in introducing the lecturer, said it was a matter of great satisfaction and pleasure to the Council of the Royal Society of Arts to see so large and representative a gathering present on that occasion. The Society endeavoured by every means in their power to keep abreast of the times, and the question of the internal combustion engine in navigation was in the front rank of the subjects of interest of the present day.

Before calling on the lecturer, he would like to read a letter addressed to himself by the late Lord Fisher, dated 22nd November, 1911. The letter was as follows :—" What I am driving at is oil alone for fuel and the introduction of war ships with the internal combustion propulsion. I do not want to be egotistical, but had I remained at the Admiralty we should be constructing a motor battle ship, and saving some 78 per cent. in fuel and 25 per cent. in space; no funnels to discover us to the enemy—no smoke—and a few chauffeurs in comparison with hundreds and hundreds of stokers and engineers. It is the first time in sea history that the British Admiralty has not led the way. We know the German Admiralty are designing an armoured cruiser that will go round the world without requiring to replenish her fuel."

The name of Lord Fisher would always remain a great one in England. His vision was wonderful. Without Lord Fisher, and without Mr. Winston Churchill's courage at the Admiralty, they would not to-day be using exclusively liquid fuel in the Royal Navy. Whilst it was a matter of regret that further progress in the utilisation of oil fuel had not been made, yet there was consolation in the fact that England led the way in liquid fuel and not the United States, in spite of the latter country possessing 80 per cent. of the world's oil. America was far behind us in the application of the internal combustion engine, and although it was a somewhat negative satisfaction, yet it was the fact that just as the Dutch and the Danes were pioneers in front of the British, so the British were much in advance of the United States at the present time.

He hoped the discussion would do something to further the wishes of their dead friend, Lord Fisher, and he was very glad to see Lord Fisher's son present at that gathering.

In calling upon Sir Fortescue Flannery to deliver his lecture, he would like to say that there was no greater authority on the internal combustion engine.

The paper read was :—

THE DIESEL ENGINE IN NAVIGATION.

By Sir J. Fortescue Flannery, Bart., M.Inst.C.E.,

Past President of the Institution of Marine Engineers.

It has been said that the age in which we live will be known to posterity as the Petroleum Age, and when one considers the vital part which petroleum in its various forms plays in the daily lives of the present generation, the accuracy of this statement will be appreciated. Petroleum provides one of the principal fuels which drive our steamships, either used direct in internal combustion engines or burned under boilers, and many of our power stations are driven in the same way. Our motor cars and aeroplanes are driven by petrol, kerosene is used for lighting and cooking in our houses, and a special form of petroleum is also used medicinally.

Proposals to use petroleum in navigation were first made by the late Admiral Selwyn, and there are some of us who can still remember the experimental boiler he had established near Charing Cross 50 years ago. The efforts of the gallant Admiral were defeated from various causes, chiefly, perhaps, the uncertainty of liquid fuel supply.

Twenty years later another pioneer appeared before the shipping world, Mr. Marcus Samuel, who had secured a concession in Borneo of oil bearing land, and who was resolved to find a market for the oil and to develop methods of consuming it in the economical production of power.

The first development of this advanced policy was to substitute oil fires for coal fires under steam boilers. This development was long and expensive, but it succeeded at last, so that in the end the Admiralty asked and received permission to send some of their R.N. Engineers to study the condition of working at sea.

The next step in advance was some ten years later, when the same pioneer began the public advocacy of Internal Combustion Engines of Diesel type for ship propulsion. The response was slow and example was necessary to be added to precept. Thus a Company was formed to build and run three motor propelled ships of large size as the forerunners of a motor ship Mercantile Marine. The " Jutlandia," with Burmeister and Wain's engines from Copenhagen, had already established a proved success, but British shipowners were hesitating and doubtful.

Messrs. Swan and Hunter built and engined the " Arum " and the " Arabis," and Messrs. Armstrong Whitworth the " Abelia," whose engines were the work of the Wallsend Slipway Company. All three ships were a definite success both for a short interval of peace trading, and then under the more strenuous conditions of war service in the years following the beginning of the Great War, and they demonstrated once and for all certain advantages of motor propulsion over steam propulsion, even when steam propulsion competed in the advanced form of steam raised by liquid fuel.

With customary foresight and enterprise Lloyd's Register Committee granted full classification to these ships notwithstanding their many novelties in the machinery.

There is no man living who has done more to bring about the Petroleum Age than our Chairman of this afternoon. Owing to his energy and foresight, a trade for the carriage of petroleum in bulk from Russia to the Far East with general cargoes homewards was started, and this pioneer venture laid the foundation of the present-day system of carriage of petroleum in bulk in tank steamers.

The first general use of petroleum was in the form of kerosene, and in this form it was burnt in lamps and used principally for lighting, and in some cases for heating and cooking. It is, of course, well known that kerosene is a refined oil with a moderately high flash point, but the oil as it comes from the earth contains, in addition to the kerosene, varying quantities of spirit, which is commonly known as petrol, and a heavy high flash oil known as fuel oil.

The principal use of petrol is as fuel in internal combustion engines of comparatively low power, and time will not permit of these being dealt with in this paper, which is intended to deal principally with engines of the Diesel type, which use the heavy grade oil of high flash point.

In the early days of the petroleum industry, when the most valuable product was kerosene, the importance of finding uses for the other constituents of the crude oil was fully realised, and in the first instance this heavy oil was and is still used as fuel under boilers. The credit for the extensive use and efficiency of liquid fuel for raising steam at the present day is, in the first place, due to Lord Bearsted, who was assisted in the technical details by my partner, the late Mr. Robert Baggallay.

In 1897 Dr. Rudolph Diesel developed the idea whereby fuel was injected into a cylinder containing air which had been raised by compression to a sufficiently high temperature to bring about combustion, and the earlier engines on the Diesel principle operated upon what is known as the four-stroke cycle, which means that one stroke in every four or in every two revolutions is productive of power.

The Diesel type engine is that arrangement by which the petroleum is ignited not by magneto electric spark, as in the earlier internal combustion engines, but by the heat generated due to high compression of the air contained in the cylinder prior to the injection of the petroleum fuel, and this system, whilst simplifying the mechanism in one direction, does introduce complications in another, but, on the whole, produces a greater simplicity and an arrangement of parts more within the compass of ordinary mechanism and ordinary engineering supervision. The credit for the invention of ignition by compression has been given to Dr. Diesel, a German engineer of high attainments, but it is claimed that an Australian engineer, Mr. Herbert Akroyd Stuart, of Claremont, Western Australia, patented the system many years earlier than Dr. Diesel, although he was never able to bring it into practical operation.

I do not propose to deal at any very great length with the details of operation, but, briefly, the four-stroke cycle in the Diesel engine is as follows :—

First Stroke.—Piston travels upwards, compressing the air in the cylinder to about 500 lbs. per square inch, thus raising the temperature sufficiently to enable combustion to take place when the fuel is injected into the cylinder very shortly before the end of this stroke.

Second Stroke.—Piston forced downwards due to combustion and consequent expansion of gases in cylinder, thus constituting the working stroke.

Third Stroke.—The piston travels upwards, expelling the products of combustion or exhaust gases through the exhaust valve, thus leaving the cylinder free to draw in fresh air through the inlet valve.

Fourth Stroke.—Piston travels downwards, drawing fresh air into the cylinder through the inlet valve, which will be compressed on the next stroke, thus completing the cycle.

As already stated in the above cycle only one effective or working stroke is obtained in two revolutions of the engine, and in order to increase the power per cylinder, the two-stroke cycle engaged the attention of engineers and the principle of this is as follows :—

First Stroke.—The piston travels upwards compressing air in the cylinder and fuel is injected shortly before the end of the stroke, as in the four stroke engine.

Second Stroke.—Piston travels downwards under energy developed by combustion of fuel, and when nearing the bottom of this stroke uncovers ports in the cylinder which allow the exhaust gases to escape on one side and fresh air to be pumped in on the other side. This air blows the exhaust gases through the exhaust ports and is known as scavenge air.

The piston then travels upwards closing both exhaust and scavenge ports, compresses the air and the previous cycle of operations is carried out.

It will thus be seen that by this means, one impulse is received every revolution on the two-cycle principle, whereas it is only obtained once on every two revolutions in the four-cycle principle.

Some difference of opinion exists amongst engineers as to the relative merits of the two-cycle and four-cycle types of Diesel engines, and in the earlier stages, owing to mechanical difficulties, principally in piston cooling and lubrication in the two-cycle engine, the most reliable types of engine were on the four-cycle principle, and such vessels as the " Jutlandia " and " Selandia" were run, I understand, to the complete satisfaction of their owners.

The two-cycle engine is under the disadvantage of having to drive a separate pump for scavenging the cylinders, and generally speaking the fuel consumption of the two-cycle engine is not quite so economical per B.H.P. as the four-cycle, as even though the greatest care is exercised in design in efforts entirely to remove the exhaust gases from the cylinder at the end of the working stroke, this is not so completely done by scavenging as by being expelled by the stroke of the piston in the four-cycle type.

Now that the difficulties of lubrication in the two-cycle engine have been overcome by means of forced lubrication, and that the piston cooling arrangements have been so greatly improved as to render them reliable, the two-cycle engine is now probably as reliable as the four-cycle, and owing to the absence of inlet and exhaust valves the cylinder covers are a simpler casting, which is a very desirable feature, as it is of the utmost importance that the design of all engines should be of the simplest form.

Until quite recent years all Diesel engines, whether two-cycle or four-cycle, were single acting, that is to say, that the pressure was only exerted on one side of the piston, but of recent years great advances have been made with the double-acting engine of various types, and these engines have been installed in large ocean going ships.

The most usual method of injecting the fuel into the cylinder so as to break it up sufficiently for complete combustion, has been to blow it through a suitable nozzle by means of compressed air, but there is also a method that is known as " solid injection," whereby the fuel is forced into the cylinder through a nozzle at very high pressure by means of a pump, and although solid injection has the great advantage of doing away with the costly and somewhat delicate air compressor, the pump pressures are of necessity very much higher than the air pressures in the air injection system, and this has been considered by many engineers to be so greatly against the solid injection system that its use is not so common as the air system. Messrs. Vickers and Messrs. Doxford are the principal exponents of the solid injection system, and it has worked with every success in their engines.

It is, of course, well-known that the Diesel engine cannot be started without external agency, and the means usually adopted is to admit compressed air from containers into the cylinders at the proper time by means of what is known as a starting valve.

This gives the necessary impulse to turn the engine, and, when the engine has been moved sufficienly, fuel is admitted to some of the cylinders. When these are running the air is then cut off, and fuel admitted to the remaining cylinders. This arrangement has proved most quick and reliable in practice, but it has the disadvantage of high pressure in the storage bottles, in order to overcome the compression in the engine. In order to overcome this disadvantage auxiliary cylinders are fitted in addition to the main cylinders in the " Polar " engine, and these cylinders when not in use for starting are used as pumps in order to supply the necessary scavenge air. A further advantage of this system is that in manœuvring the engine no cold air is admitted to the hot working cylinders.

The experience of the writer, in so far as the Diesel engine is concerned, has mainly been in connexion with the use of the Diesel engine for purposes of marine propulsion, and from the point of view of heat efficiency and consequent fuel economy, the Diesel engine is admittedly the most efficient machine in existence for the propulsion of ships.

A good steam plant may be considered to be working satisfactorily when its consumption of coal is 1.8 lbs. per B.H.P. per hour, and this corresponds to about 1.4 lbs. of oil fuel per B.H.P. per hour when the fuel is used under boilers for raising steam.

Most Diesel engines, however, burn about .40 lbs. of oil per B.H.P. per hour, and it will, therefore, be seen that so far as weight of fuel is concerned, the Diesel engine uses approximately 4½ times less fuel than the coal fired steam plant, and about 3½ times less than the steam engine of similar power when steam is raised by means of liquid fuel.

Apart from the saving in the fuel bill the effect of this economy is,

1. Either to enable the range of operation of the vessel to be increased, or,
2. To reduce the amount of bunkers carried, thus enabling more cargo to be put on board.

In addition to the saving in the quantity of bunkers to be carried, owing to the nature of the fuel, it is possible for it to be stowed in places which would be quite inaccessible for coal, such as in the double bottom or in the peak tanks

In the early days of the use of the Diesel engine for marine propulsion it was in nearly every case considered highly desirable that two sets of engines driving twin screws should be fitted. This was partly desirable on account of the limited knowledge of the Diesel engine, which gave rise to some doubt as to its reliability, in view of which it was necessary to have one set which could be worked even if the other were out of order, and partly because of the comparatively small diameter of the cylinders in the earlier motors, which prevented a large power per cylinder being developed, thus necessitating a large number of cylinders. It was, therefore, more economical of space to put these cylinders on two shafts than to put them on one shaft, and thus unduly lengthen the engine room.

Now that the Diesel engine has passed through its initial stages and may be regarded as a reliable means of propulsion, and as larger powers per cylinder can now be developed, many builders have put the cylinders on the one shaft, as in the case of marine steam engines. This arrangement has the advantage of considerable saving in the initial cost, reduces the number of working parts, and thus enables a considerable reduction to be made in the number of the engine room staff, so that with the modern Diesel engine a very considerabe saving in the number of the engine room staff can be effected.

Some engineers have turned their attention to fitting high speed Diesel engines, and reducing the propeller shaft speed to a suitable limit by means of electric transmission. This system has the advantage of a saving in weight, and the additional advantages that the Diesel engines and dynamo may be placed in any convenient position in the ship, and if it is desired to run below the maximum power the required number of engines may be cut out altogether, thus enabling the other engines to run at their most efficient load.

The supporters of the Diesel engine have further urged in its favour that so far as obtaining power is concerned in actual manipulation, the human element can be eliminated to a much greater degree than in the case of the coal-fired steam engine, where power is dependent upon the skilful handling of the fires and firemen, whereas in the Diesel engine if additional power is required, it is within certain limits only necessary to increase the admission of fuel, and the necessary power will be forthcoming.

With reference to this I would like to utter a word of warning, and in the first instance to advise all who intend to instal Diesel engines to have them made of ample power for the work which they would be called upon to perform, as there is nothing easier than for an engineer, under the influence of either the Captain or his owner to overload his engines (which can be done by merely turning a screw) and although to begin with no immediate bad results may be felt, yet the life of the engine will be seriously shortened, and the bills for upkeep greatly increased if overloading is permitted.

Now that Diesel engines of both the four-cycle and two-cycle single-acting type may be considered to be beyond the pioneer stage, and to be commercially reliable, the principal objection to their adoption would appear to be the high initial cost in construction, and so far as can be seen the approximate figure would be in the neighbourhood of 30 per cent., but with the more extensive adoption of Diesel engines, and with possible standardization of design, it is probable that this figure can be very materially reduced. It must, however, be fully borne in mind that both workmanship and material in the Diesel engines must be of the very highest quality, as owing to the varying stresses and the high initial pressures in the cylinders, if any bad work or material is incorporated, then trouble and probably serious expense due to breakdown are almost certain to ensue, and even if actual breakdown does not take place, expense which could otherwise have been avoided is certain to be incurred in connection with overhaul.

There is a further point which must be borne in mind by all intending users of the Diesel engine for marine propulsion, and that is the question of the cost of upkeep and depreciation, of which no complete figures can, of necessity, be yet available, but from my experience I see no reason why the depreciation nor the cost of upkeep should be greater in the Diesel engine than in the steam engine, provided that engines of sufficient power which have been accurately constructed of the best material, and which have received proper attention in running, are installed.

It has been urged against the economy in consumption of fuel that the amount of lubricating oil used by the Diesel engines is in excess of the amount used by steam engines, and although this may be to some extent true, the difference is not sufficient to be considered in any way as compared with the saving in fuel, and in view of the fact that forced lubrication is used and that separators are provided in nearly every Diesel ship for cleaning the lubricating oil, its consumption is reduced to a minimum.

As already stated, the single-acting Diesel engines may be divided into the four-cycle and two-cycle types, and the advantages of each particular type have already been mentioned. The principal types of four-cycle single-acting engines are :—

1. Burmeister and Wain.
2. North British.
3. Tosi.
4. Vickers.
5. Werkspoor.

While the principal two-cycle engines are the

1. Doxford.
2. Fullagar.
3. Polar.
4. Sulzer.

In addition to the above there is also the Still engine, which consists of a two-cycle Diesel engine on the upper side of the piston and a steam engine underneath, and it may, therefore, be regarded as a single-acting engine from the Diesel point of view, although its action as a whole may be regarded as double-acting, and its evolution has arisen partly with a view to utilising the heat of the exhaust gases from the Diesel part of the engine to generate steam, and partly to obtain a double-acting engine, with its consequent smoothness of running without the mechanical difficulties which are at present inseparable from double-acting Diesel engines.

BURMEISTER AND WAIN ENGINE.

The original designers and builders of this engine were amongst the very earliest Diesel engine builders successfully to instal Diesel engines on board ship, and the " Jutlandia " and " Selandia," when they first came out, may be said to have been the beginning of a new era in modern propulsion. Both these vessels have, I understand, always worked most satisfactorily and are still doing so. This type of engine is probably more used in modern-sized ships to-day than any other type. As already stated, the engine is of the four-cycle single acting type, and fuel injection is carried out by means of compressed air.

One interesting feature of the engine is that fresh water is employed both for cooling the pistons and the cylinders, and this has the advantage of avoiding the risk of a deposit of salt on the surfaces to be cooled, and also obviates any risk of sand or mud going into either the water jackets or the pistons.

The pump for forcing the cooling water through the engine, and also the pump for supplying the lubricating oil to the various working surfaces, are driven independently of the main engine. The only auxiliaries driven off the main engine are the compressor, the piston lubricating pump and the fuel pumps. The great advantage of this system is that before the engine is started, or when the engine is temporarily stopped, the supply of lubricating oil and cooling water is maintained, and it is very desirable, even if the circulating water pump and the lubricating oil pump are driven off the main engines, that means of supplying the engine with both oil and circulating water should be provided when the engine is not working, as, before starting up, it is of the utmost importance that the jackets and pistons should be full of water, and that all working parts should be efficiently lubricated. The cam shaft is situated at a level of about the bottom of the cylinders, and is driven by spur gearing. There are four valves in each cylinder cover for suction, exhaust, starting air and fuel injection. These valves are worked by push rods from the cam shaft.

Reversing of the engine is carried out by sliding the cam shaft in a fore and aft direction, thus bringing the astern cams into operation. These cams have the effect of opening the various valves at a different period of the stroke, thus enabling the impulse to be given when the piston is in a different position, and making the engine run in the opposite direction.

Messrs. Burmeister and Wain build an engine which at full load runs at about 85 revolutions per minute, and this is from the point of view of propeller efficiency a very satisfactory speed.

VICKERS' ENGINE.

Engines of the Vickers' type have been very largely used in British submarines, and probably the most outstanding feature in this engine is that solid injection is used in order to atomise the fuel in the cylinder, the oil being delivered at a pressure of about 4,000 lbs. per square inch.

Sea water is used for cooling both the cylinders and pistons, and in order to minimise the deposit of scale and to prevent the deposit of sand or mud, a special means of producing eddies is provided.

The valves are actuated by means of rods, which are attached to rocking arms, which are carried by an eccentrically-mounted shaft, and these rocking arms are in turn actuated by means of the cam shaft. Manœuvring is effected, firstly, by turning the eccentrically mounted shaft, which has the effect of lifting the rocking arms clear of the cams on the cam shaft, and then sliding the cam shaft in a fore and aft direction, thus bringing either the ahead or astern cams into operation.

The speed of this engine is controlled both by means of adjusting the lift of the fuel valve, or by altering the lift of the suction valves of the fuel pumps.

WERKSPOOR ENGINE.

The outstanding feature of this engine may be said to be that the cylinder cover is cast in one with the liner instead of the liners being separate castings, as is the case in every other type of marine Diesel engine, and the advantage of this system would appear to be that it is possible for the cooling water to be carried to the top of the liner, at which point the working temperature is highest. The casting is, of course, more difficult to make, but very satisfactory results have been obtained by this type of engine.

The method of supplying fuel to the cylinders also differs considerably from the usual practice, as the fuel pump supplies fuel to a receiver, which is placed above the cylinders, and in which the oil is subjected to a high pressure by blast air being admitted to the container. The fuel then flows through a distributing box direct to the fuel valve, by which it is admitted under blast pressure to the cylinder.

The levers actuating the valves are mounted eccentrically upon the manœuvring shaft, and these levers are in turn actuated by the cam shaft, and manœuvring is effected by twisting the manœuvring shaft, which has the effect of raising the rollers on the valve lever above the cams, and owing to an askew motion given to the levers by the manœuvring shaft, the levers are moved in a fore and aft direction over either the ahead or astern cams on the cam shaft. This arrangement has the advantage that it is unnecessary to move the cam shaft in order to manœuvre the engine, but it has the disadvantage that whilst in the astern position the valve levers are working out of line. In this engine salt water is used for cooling both pistons and cylinders.

NORTH BRITISH DIESEL ENGINE CO.

A type of engine has been evolved by the North British Diesel Co. which contains many interesting features. The valves are actuated by means of short push rods driven off the cam shaft, which is mounted eccentrically, so that when it is rotated the cams are dropped out of their normal position clear of the rollers on the push rods, thus allowing the shaft to be moved in a fore and aft direction, bringing the desired set of cams into operation.

Sea water is used for cooling both pistons and cylinders, the piston cooling water passing through the piston rods.

Fuel is injected into the cylinders by means of compressed air, and the speed is regulated by altering the lift of the suction valves of the fuel pumps.

TOSI ENGINE.

This engine represents a very great departure from the usual principles of Diesel engine design, in that a single valve in the cylinders is used both for inlet and exhaust, and in conjunction with this valve is a distributor or director valve, which places the valve in the cylinder cover in communication with an air passage during the suction stroke, or with the exhaust pipe during the exhaust stroke. The valve in the cylinder cover is driven by a cam shaft in the usual way, while the distributing valve is driven by means of an eccentric off the cam shaft. The number of mushroom valves in the cylinder cover is reduced, and, as cold air is drawn over the valve every two revolutions, its temperature is kept down, and it is not, therefore, so liable to corrosion as is the case in the exhaust valves in the usual design of four-cycle engine.

An arrangement is also provided by which air is drawn from the underside of the pistons, and after this air has been heated by passing in close proximity to the exhaust pipe, it passes into the cylinder, and this initial heating should be a considerable help towards perfect combustion in the cylinder.

Sea water is used for cooling both pistons and cylinders, and spiral projections are cast on the jacket side of the liners in order to give the water a higher velocity at the top of the jacket, so as to counterbalance the high temperature of combustion at this point.

The method of manœuvring is also original, and is effected by means of forking the ends of the valve levers, so that the rollers may be slid in a fore and aft direction, and thus brought either over the ahead or astern cams on the cam shaft as may be desired.

TWO-CYCLE ENGINES.

DOXFORD TYPE.

This engine is of a type known as the "opposed piston type," and the general arrangement is as follows:—

Each cylinder contains two pistons, which move towards each other on the compression stroke and move apart during the working stroke, the upper piston travelling upwards and pulling the crank, to which it is connected, upwards with it, whilst the lower piston travels downwards, driving the crank to which it is also attached. When the pistons get to the end of their stroke they uncover ports both in the top and bottom of the cylinder. Scavenge air is admitted through the ports at the bottom and the exhaust gases are carried away through the ports at the top. By this means a very satisfactory arrangement of scavenging is possible, and in view of the simplicity of construction the engine has given very satisfactory results. Fuel is admitted between the pistons at the end of the compression stroke, and the normal speed of rotation is about 77 revolutions per minute, which enables a satisfactory propeller efficiency to be obtained.

Solid injection of fuel is adopted in this engine, the pressure being about 9,000 lbs. per square inch, which is about double the pressure used in the Vickers engine.

Manœuvring is carried out by moving the cam shaft in a fore and aft direction, so bringing either the ahead or astern cams which work the fuel and starting air valves into action. Piston cooling is carried out with fresh water.

The compression in the cylinder is lower than usual, being in the neighbourhood of 300 lbs. per square inch, and in order to raise the heat of compression an uncooled plate of nickel steel is fitted in each piston head, which provides the requisite heat in order to produce combustion after the engine has been first heated up by steam.

FULLAGER ENGINE.

This engine is also of the opposed piston type and consists of units of two cylinders, each containing two opposed pistons, each upper piston being connected by cross rods to the crosshead of the lower piston in the other cylinder; so that while the lower piston in one cylinder is driving the crank to which it is directly attached downwards, the upper piston in the same cylinder is dragging the crank, which is attached to the lower piston of the other cylinder upwards. By this means the number of cranks is kept down to a minimum and an even turning movement is obtained. The cross rods are, of course, attached to crossheads connected with the upper piston, and these crossheads are used to form scavenge cylinders to provide scavenge air. As in the Doxford engine, the pistons at the end of their stroke uncover scavenge ports in the bottom of the cylinders and exhaust ports in the top of the cylinders.

In this engine air injection for atomising fuel is employed, and the fuel valves are situated in the centre of the cylinder in the compression space between the pistons.

POLAR ENGINE.

When this engine was originally designed scavenge cylinders were arranged in line with the working cylinders, and these scavenge cylinders were used to start the engine, which proved a very satisfactory arrangement, as starting air of a comparatively low pressure could be used, and the engine was not subjected to the disadvantage of cold starting, air being injected into the hot working cylinder whilst manœuvring. There was the further advantage that the necessity of a starting valve in the cover of the working cylinder was removed, thus simplifying the design of the cylinder cover, which only contained the fuel valve. This idea has been further developed in the Neptune engine, in which one scavenge or manœuvring cylinder is fitted below each working cylinder in engines up to about 1,000 B.H.P. It has recently, however, been found in engines of large power that the scavenge cylinder beneath the working cylinder unduly adds to the height of the engine, and this method of scavenging has, therefore, been superseded by separate scavenge pumps or by turbo-blowers. The injection of fuel into the cylinder is effected by means of compressed air and the speed of the engine is regulated by controlling the lift of the suction valves of the fuel pumps.

The cams for actuating the fuel valves are mounted on sleeves on the cam shaft and manœuvring is effected by sliding these sleeves with the cams into the required position for either ahead or astern running. In order to avoid the necessity of lifting the cam rollers off the shaft the edges of the cams are tapered, thus permitting the sliding just mentioned to be carried out.

SULZER ENGINE.

Probably the most original feature in the design of Messrs. Sulzer's two-cycle engine is the provision of auxiliary ports above the level of the exhaust ports and of the ordinary scavenge ports, by means of which air is admitted into the cylinders after the exhaust ports are closed. Thus, before compression the air in the cylinders is at the pressure of the scavenging air and a small degree of super charging is thus obtained. The admission of air through the auxiliary ports is controlled by means of a valve situated in the scavenge air pipe, which valve is closed during the working stroke, and, therefore, the portion of the cylinder containing the auxiliary ports is available for useful work during the working or downward stroke of the piston.

Manœuvring is effected by altering the thwartship position of the rollers on the valve levers, and by this means the position in the stroke at which the starting and fuel valves are opened can be controlled. Sea water is used for cooling both the pistons and cylinders, and the piston cooling is effected by water being forced through a telescopic pipe on the downward stroke of the piston, travelling through the piston and being discharged through another telescopic pipe.

One of the most recent ships to come before the notice of the public is the "Aorangi," which was built by Messrs. The Fairfield Shipbuilding and Engineering Co. for the Union Steamship Company of New Zealand. This vessel has a load displacement of about 22,000 tons and is designed for a service speed of 18 knots. She is fitted with four six-cylinder single-acting Sulzer motors, having an aggregate B.H.P. of 13,000 on the four shafts at a speed of about 127 R.P.M.

STILL ENGINE.

This engine has recently aroused a great deal of interest, as it has for its principal object the utilisation of heat, which in the ordinary Diesel engine is wasted both in the exhaust gases and in the cylinder jackets.

The general arrangement consists of a two-cycle Diesel engine and below this a steam cylinder, in which the steam acts on the underside of the piston.

Instead of the ordinary arrangement of cooling jackets the walls of the Diesel cylinder are made as thin as possible, and fresh water is circulated throughout the jackets and pistons of the engine; the water thus heated passes direct to a steam boiler and the exhaust gases from the Diesel engine are also led to this boiler, where more steam is generated by this means. The steam so generated passes to the steam cylinders below the Diesel cylinders and contributes towards the power of the engine, and it is estimated that this additional power from the waste heat is about 20 per cent. of the power developed by the Diesel portion of the engine. This engine has been installed in a large motor yacht and in the M.S. Doluis, and has, I understand, given satisfactory results.

ADVANTAGES OF DOUBLE-ACTING ENGINES.

With the necessity for obtaining larger powers within a reasonable engine room space, and with the desire to economise weight, engineers have for several years past turned their attention to the production of the double-acting Diesel engine, which, in addition to increasing the power per cylinder, also reduces the variation of turning moment on each crank, thus reducing the stresses upon the engine and ultimately upon the structure of the ship.

Double-acting Diesel engines have been designed both upon the two-cycle and four-cycle principles, and in most cases what may be called the piston rod engine has been adopted. This form of engine is subject to the disadvantage that the piston rod is exposed to the full heat of combustion, that the high initial pressure in addition to the hot rod make the stuffing box difficult to keep tight, and the shape of the cylinder bottom due to the rod passing through the centre is not of the most suitable form for efficient combustion.

These difficulties have to a great extent been overcome, and the principal types of double-acting Diesel engines are as follows :—

1. Burmeister and Wain.
2. North British Diesel.
3. Werkspoor.

1. BURMEISTER AND WAIN.

This engine is designed to work upon the four-cycle principle, and many of the most notable features in the Burmeister and Wain single-acting engine have been incorporated.

The portion of the engine above the piston may be generally considered as the working portion of the Burmeister and Wain single-acting engine with similar type of cylinder covers.

The difficulty of overheating of the piston rod and possible trouble with the piston rod stuffing box has been overcome partly by causing combustion below the piston to take place in a separate chamber, at such a distance from the rod that the extreme heat of initial combustion would not appear to impinge directly upon the piston rod, and, secondly, by fitting a cast iron sleeve over the rod. This sleeve is provided with piston rings and works as an ordinary piston, thus removing the difficulties attendant upon the full pressure in the cylinder having to be resisted by the packing of the stuffing box. The sleeve and the stuffing box are both cooled by oil or water, and I understand that the results on the experimental engine have been very satisfactory.

The cam shaft is, I understand, driven by means of a chain, which is a novel arrangement in Diesel engines of large power, and reversing will be effected in the usual way by sliding the cam shaft in a fore and aft direction, so as to bring the desired cams under the tappets.

Another somewhat novel feature of this engine is that oil is used for piston cooling, and this has the advantage that, should any leakage in the piston cooling arrangements occur, no damage to the lubricating oil by mixture with water takes place.

Two sets of these engines of 6,750 B.H.P. each in six cylinders is being installed in the Swedish passenger liner "Gripsholm," and it is estimated that she should have a sea speed of about 17 knots.

2. NORTH BRITISH DIESEL ENGINE CO.

The double-acting engine evolved by the above Company is amongst the most interesting of modern engines from the point of view of novelty of design, and the great differences between it and all other types of either single or double-acting Diesel engines is, that piston rods are dispensed with, and in order to open and close the scavenge ports, the cylinder itself slides through a small distance, which is an entirely new feature in Diesel engine design.

The principal parts of the engine consist of the framework which carries, what may be termed, a cylindrical plug at both top and bottom; these plugs are fitted with piston rings and may be regarded as the top and bottom cylinder covers. Over each of these plugs is fitted a cylinder, the top and bottom cylinders being fastened together by means of tie rods. Scavenge ports are provided at the outer end of each cylinder, while the exhaust ports are provided at the inner ends. A piston with a central crosshead which carries a connecting rod with a long fork works in the cylinders, and the arrangement is such that during the compression stroke at either end the piston covers the exhaust ports, while the position of the cylinder relative to the plugs in the end is such that the scavenge ports are closed.

Towards the end of the compression stroke, fuel is injected into the cylinder through valves in the plug cover, and at the end of the working stroke, owing to the movement of the cylinder actuated by levers from the crosshead, the scavenge ports are opened, and at the same time the exhaust ports at the inner end are opened due to the movement of the piston. It will be obvious that while the working stroke is in progress in one end of the cylinder the compression stroke is taking place in the other end.

This arrangement has the advantage that no piston rod is required, and that the shape of the combustion space at both ends of the cylinder can be made of the most suitable form for the most efficient combustion. The injection of fuel is carried out by means of compressed air.

Owing to the length of the piston the connecting rod is of unusual length, and, therefore, the ratio of throw of crank to length of connecting rod is larger than usual, thus tending to minimise the stresses throughout the engine.

Owing to the comparative lightness of the cylinders, and to the ease with which the connecting pieces between the two portions of each cylinder can be removed, the overhaul of the engine is a comparatively simple matter, as it is possible by simply releasing the ties between the top and bottom of the cylinder to examine either the top or the bottom portions of the piston and cylinders, as may be desired.

In the original design of this engine it was intended that the fuel valves should be actuated by the same mechanism which caused the cylinders to slide, but fears were entertained that some sticking of the valve might occur in the lower portion of the engine, and as time did not permit of this arrangement being thoroughly tried out in the shop before the engine was required for service at sea, it was decided to fit a cam shaft in the usual way, as ample experience of this method of valve actuation was at the disposal of the builders.

A three-unit set having a cylinder bore of 24½" x 44" stroke and designed to give 2,000 B.H.P. at 100 R.P.M. has been installed in the M.S. " Swanley," which is a vessel built to the order of Messrs. Harris and Dixon by Messrs. Barclay, Curle and Co., Ltd.; the vessel has a displacement of about 12,600 tons, and her designed speed at sea was 10½ knots. This vessel has already made several voyages, and, I understand, the running of the machinery has in every way proved satisfactory.

3. WERKSPOOR.

This engine may briefly be described as a full Diesel engine on the upper side of the piston and a semi-Diesel engine on the lower side, that is to say that the usual compression of about 500 lbs. per square inch is used on the top of the piston, while a lower pressure, probably about 250 lbs. per square inch, is adopted beneath the piston, and in order to overcome the difficulties due to combustion taking place in close proximity to the piston rod a separate combustion chamber is arranged below the piston.

This combustion chamber can be made of the most advantageous shape for efficient combustion, and the inlet, fuel and exhaust valves are situated in it, thus greatly reducing the difficulty of actuating the valves beneath the piston.

The engine works on the four-cycle principle on both sides of the piston, and air injection is used for forcing the fuel into the cylinder.

As the compression beneath the piston is not sufficiently high to produce self ignition when the engine is quite cold, the engine is started as a single-acting engine above the piston, and means are provided for the exhaust gases to have access to the combustion chamber below the piston by keeping the exhaust valves open. The exhaust gases consequently heat an uncooled liner which is situated in the lower combustion chamber, so that when fuel is injected the temperature of the air due to the combination of compression and hot liner is sufficient to produce ignition.

A single-cylinder experimental engine of the four-cycle double-acting Werkspoor type has been erected in the shops of Messrs. The North Eastern Marine Engineering Co., at Wallsend, having a brake horse power of about 600, and very satisfactory and encouraging results have been obtained on the test bench under conditions approximating as nearly as possible to those of service at sea, the oil consumption being about .42 lbs. per B.H.P. per hour.

AUXILIARY MACHINERY.

One of the most difficult questions to be solved in a Diesel ship is the most suitable form of auxiliary machinery to be fitted, and in the early days it was considered by many engineers better to fit steam auxiliaries both on account of their comparative cheapness and on account of their reliability. Of recent years electricity as applied to auxiliaries, such as windlass, winches and pumps, has made such rapid progress, and marine engineers have become so much more accustomed to its use that the electrical auxiliary may now be regarded as practically as reliable and free from breakdown as its steam brother. Therefore, at the present time the question of the nature of the auxiliaries is governed principally by the trade in which the vessel is to be employed, it being borne in mind that the initial cost of steam auxiliaries is considerably lower than electrical auxiliaries; for instance, in the case of a general cargo steamer, where steam will not be required, electrical auxiliaries will, from an engineering point of view and economy in running, make a more satisfactory job, whereas in tank ships, where steam may be required for driving the cargo pumps or for heating the cargo in the tanks, then a proportion of the auxiliaries might be steam driven so as to cut down the initial cost, but it is desirable that a sufficient number of auxiliaries shall be electrically driven to enable the vessel to be worked at sea without any steam, if desired.

ENGINEERS.

One of the most important factors in connexion with the successful running of any internal combustion engine is that the men who have charge of the machine shall be fully competent to look after it, and it is, therefore, of the greatest importance both to ship owners and builders that the machinery, whilst running, should be in the hands of fully qualified marine engineers. Owing to the rapid growth of the Diesel engine of recent years the number of men qualified by experience at sea with Diesel engines is at the moment somewhat less than the demand, and the course which has been adopted by many of my friends who have embarked on Diesel tonnage has been to send the more adaptable of their engineers who have had experience with steam engines into the works of the Diesel engine builders, in order to acquaint themselves with every detail of the machinery which will ultimately come under their charge, and by this means a staff of engineers fully capable of successfully running Diesel engines has been created.

It has been already very clearly demonstrated that the conditions under which allowances from gross tonnage are made for propelling machinery, and coal bunkers and light and air space, differ entirely in the cases of steam engines and internal combustion engines, both by reason of the absence of main boilers in the latter, and also because of the fact that whilst the stowage of coal necessarily occupies space from which cargo would be shut out, liquid fuel may be stowed where ordinary cargo could not be carried, these latter factors increasing the freight earning power of the ship, although the engine room space, upon which the 13 per cent. of the gross tonnage which must be occupied by machinery space to qualify for full allowance for fuel, is sometimes unnecessarily enlarged in order to reach this qualification. The whole questionof allowance in regard to machinery space and fuel requires reconsideration by the Board of Trade and, no doubt, the increase in motor tonnage will bring about some changes at an early date in the methods of tonnage measurement as applied to motor ships.

FUTURE NAVIGATION.

One great hindrance to the development of large powers has been the limitation of the possible size of cylinders, having regard to the enormous initial pressure of the gases, and this limitation of size of cylinders has caused not only their multiplication upon each shaft, but the multiplication of shafts where very large power is required. The greatest power hitherto placed on board any one ship has been the case of the " Aorangi," and this great step in advance of building a quadruple screw motor ship of 18,500 tons gross is due to the fine enterprise of the Fairfield Shipbuilding Co., and the Union

S.S. Co., of New Zealand, and the thanks of the engineering profession generally are due to them, not only for their enterprise, but for the liberality with which they have thrown open their trials to the observations of their brother engineers. This ship on her trial trip obtained a speed of 18½ knots when only three of the four propellers were at work, and her future success in ordinary working at high speed may, therefore, be anticipated with great confidence.

Whilst the number of Diesel propelled sea-going ships at the outbreak of War in 1914 was 297, the number towards the close of 1924 had increased to 1,950, or rather more than six-and-a-half times in the ten years, and, as regards new construction now in progress, something under one million tons of shipping is now being built for propulsion by internal combustion engines, whilst slightly over one and a half million tons of new construction is being built for propulsion by steam engines. These figures give support to the belief that in a comparatively short time the Diesel engine will almost wholly displace the steam boiler at sea, and this change might be expected to eventuate with ever-increasing rapidity if the cost of internal combustion engines should be reduced in proportion to a more reasonable basis of comparison per horse power.

The fact, however, that development is still proceeding with rapid strides of design towards the double action type, and the consequent increase of power in proportion to weight, has as yet prevented standardisation to anything like the extent which had developed in triple expansion steam engines for sea-going purposes. No type of machinery lends itself more thoroughly to standardisation and labour saving in manufacture than internal combustion engines, and there is no doubt that when the present developments are more advanced, standardisation will reduce the cost to such a large extent as so to encourage the general use of Diesel machinery for navigation, that only for special purposes will the steam engine be able to hold its own in competition.

DISCUSSION.

THE CHAIRMAN, (LORD BEARSTED) in opening the discussion, said they had listened with the deepest interest to the illuminating paper read by Sir Fortescue Flannery. He had referred to the "Arum," the "Arabis" and the "Abelia." Those vessels had been called into being because he (the Chairman) had not been satisfied with the idea that the majority of the engines of the day were being built by foreign firms, and he was extremely anxious that British builders should take up the internal combustion engine, which, he thought, would most certainly supersede the steam engine. He considered himself most fortunate in the builders he selected, viz., Messrs. Swan and Hunter, Wigham Richardson and Messrs. Armstrong Whitworth. It was impossible to overrate the influence which Sir George Hunter had exercised in the matter of the application of the internal combustion engine. All who knew Sir George felt safe in placing a boat in his hands, and if things were not satisfactory in any way, it was quite certain he would see them through their troubles. Every one of the three ships mentioned had been sunk by German submarines during the war, but they survived long enough to prove the excellence of the internal combustion engine beyond any shadow of doubt.

The Chairman went on to demonstrate, by means of slides, how in the case of the steam-driven ships the engine room and the boiler room casing took up space which was economised in the case of the oil-driven ship, while in addition the fore and aft peaks, which in the steamship could not be utilised with effect, were available for the storing of fuel in the motor ship. The tank under the engine room was also a most useful storing place for oil fuel. It was probably a matter of great surprise to the general public and those not technically concerned with these matters to learn that with the internal combustion engine no bunker spaces at all were required, because the consumption of oil was so incredibly small that the spaces which in a steamship were not utilised, such as the double bottom, could be used for the purpose of storing oil fuel up to the amount of 900 tons in a ship of 6,000 deadweight, and this provided the additional advantage in that it saved the taking in of ballast.

The total consumption of the main engines of the "Arum" and her sister ships was 6 tons of oil per day. With coal it would have been about 24 tons a day. As showing the enormous economy effected by the use of the internal combustion engine a comparison might be made of the consumption of the main engines with that of the donkey boilers, which were quite small things. Nowadays, as Sir Fortescue Flannery had stated, electricity was very largely used for the working of auxiliary engines, but when the three ships mentioned were built, electricity had not been much developed for this purpose. In the case of the "Arum," a ship of 6,000 tons, 6 tons only of oil fuel was required for her propulsion at a rate of 9 knots, and yet she required no less than 3 tons of oil fuel per day for her donkey boilers alone. The latest figures for a ship of 10,000 tons, making 9½ knots, showed that the fuel consumption was 45 tons of best Welsh coal (a thing they did not often get), 28 tons of oil for steam, but only 12 tons for all purposes with the Diesel engine. It was amazing and almost incredible to realise that for most voyages not more than 150 tons of oil fuel were required with the Diesel engine.

A further slide showed the "Laconia" bunkering at the Petroleum Company's station in Hong Kong, and the Chairman thought it should give a sense of security to the users of oil to contemplate that the great petroleum companies had spent millions of pounds in providing such stations, of which there were 120 in all scattered over all parts of the world. The "Laconia" took in normally 550 tons of oil fuel per hour. Probably, with the Diesel engine, she would not have needed 550 tons altogether. The whole of the superstructure about the funnel went by the board in the case of a Diesel engine driven ship. No funnel at all was required.

With Diesel engine ships there was a much larger cargo-carrying capacity, whether by weight or measurement, and there was very little cost or delay in entering ports since the Diesel engine ship, which perhaps only required to take 50 or 100 tons of fuel, did not need to go alongside the quay as in the case of coal bunkering, but had a barge brought off to her from which the oil was taken on board. Under such conditions a ship could be under way again at the end of half-an-hour. This state of things had brought about a revolution in shipping matters, because while it might not be worth while for a ship to go into port, it was well worth while to spend half-an-hour in replenishing fuel if it enabled 300 tons of additional cargo to be carried. At most ports of discharge oil could be obtained for motor ships, thus enabling them to undertake a fresh voyage without being compelled to deviate for bunkers.

Sir George Hunter, with great enterprise, had developed a British designed engine, though the late Lord Pirrie, who whole-heartedly believed in the Diesel engine, was content to copy the Burmeister and Wain system, being responsible for having more Diesel ships afloat than any man living.

The lecturer had referred to the "Aorangi." The engines of that ship were built by the Fairfield Shipbuilding and Engineering Company, but they were designed in Switzerland. It seemed a great pity that with the wonderful brains our builders possessed they should still to-day have to go to foreigners—and especially to Switzerland, who had no ships—for designs for their marine engines. That position was, however, a little redeemed by the reflection that those engines were being constructed and put into the ship in Great Britain. The builders guaranteed to the owners two alternatives, viz., a saving in the size of the ship of 25 per cent., or, alternatively, an increase of the passenger accommodation by 25 per cent. He was glad to think that it was the latter alternative which the owners chose. Let them just consider what that meant. It would mean that they would be carrying hundreds more passengers than would have been possible with a steam-driven ship of the same size, because the amount of space occupied by stokers was necessarily very large, and all that space could now be utilised for passengers, to say nothing of the very great saving in the stokers' wage bill.

Sir Fortescue Flannery had mentioned the Swedish passenger liner, "Gripsholm," a very interesting ship only just recently launched. She was the first Atlantic liner of this type built by Messrs. Armstrong Whitworth, but he was sorry to say that her engines were being made in Copenhagen. She had 4-cycle double-acting engines of the Burmeister and Wain type, and the most interesting point about her—and it was an immense step forward—was that she was giving 1,100 B.H.P. per cylinder, an enormous advance.

For auxiliary machinery electrical power was, in his opinion, essential because the cost of fuel for steam was quite prohibitive, except where it might be required, as often did happen, to thaw the fuel in the tanks.

The time had come when the education of intending Diesel engineers should be considered. This was a most vital matter, and every inducement should be offered to the Universities to take it up. Lloyds had always been, as Sir Fortescue Flannery had said, most broadminded and helpful. He could remember the time when, like most pioneers, they were beset by great difficulties, and in those days they received nothing but help from Lloyds. In that connexion he would like to mention the name of Mr. Milton, who had now retired, but whose broadminded attitude helped enormously the introduction of liquid fuel, and, so long as he was at Lloyds, the internal combustion engine. It was only fair to say that Mr. Milton's successors were following upon the same lines, as there had already been great modifications in the rules which militated against the internal combustion engine. They were at one time compelled undergo an annual survey, but that had been changed and the inspection was now a bi-annual one, and the actual overhaul was only once in four years.

It was not altogether satisfactory to find that whilst on the Continent no less than 80 per cent. of the tonnage which was being built was for internal combustion engines, in Great Britain the proportion was only 36 per cent., though it might well be that that 36 per cent. represented more in volume than the whole 80 per cent. of the Continental tonnage.

A great economic question was involved in the change from coal to oil. Taking as a basis the production of oil in 1924, which was about 160,000,000 tons, and assuming that 50 per cent. of it might be used for internal combustion engines, that would mean that approximately no less than 300,000,000 tons of coal would be displaced by the newer power. It would be mad to ignore this. If there was a falling off in coal exports it must be realised that so far as the use of oil in ships was concerned it was going to continue and to increase. When it was considered that Diesel oil could be purchased at almost any port throughout the world at the price of £5 per ton—and that was higher than the average—the great companies having, wisely, he thought, decided to make a flat rate for oil throughout the world, that was equivalent on a very liberal calculation to not more than 25s. a ton for coal, and he believed in most ports the average cost of coal was very much higher than that.

Having called attention to the fact that the Diesel engine ship need not take more than 150 tons of fuel on the longest voyage, he would like to take by way of exemplification of that statement the voyage to the Far East. Tanks were provided at Malta, Gibraltar, the Suez Canal, Perim, Colombo, Penang, Singapore, Hong Kong, Shanghai and Yokohama, and the distance between any two of them did not involve the necessity for more than 150 tons of bunkers.

The revolution in methods of bunkering thus brought about, though so great in the case of the Mercantile Marine, would be immeasurably greater in the case of the Royal Navy. If every unit in the Navy were fitted with the Diesel engine, his estimate, which was based upon fact, was that the total annual requirements of the Navy would not exceed 400,000 tons. The problem of maintaining supplies would be solved, because supplies could be obtained from any of the three oilfields situated in the British Empire, and the saving in cost might well make the Chancellor of the Exchequer's mouth water.

He regretted to have to express the opinion that the Admiralty had not taken the best steps to bring about such a desirable consummation. He had explained how the matter was regarded by Lord Fisher, but so far as he was aware not a survey ship nor even a transport, which was a type of ship probably more likely to profit by the change than any other, was yet provided with Diesel engines. He was very glad to see Lord Birkenhead present, and probably if he were at the Admiralty they would see a move made. By inviting the co-operation of and tenders from shipbuilders, not only would that class of ship benefit, but it would be more than likely that actual vessels of war would be designed, and he ventured earnestly to commend that course to the Admiralty.

An extremely interesting proposal had been put before him by one of the shipbuilding and armament firms, which made the suggestion that if they could take a vessel similar to the "Penelope"—a well-known class of cruiser having a displacement of 3,520 tons and a speed of 28 knots—by re-arranging the vessel and introducing Diesel machinery it would be found possible to fit four sets of engines, giving a total horse power of 24,000 on a weight of 1,350 tons and a speed of 26 knots. It would be seen from this that by the substitution of Diesel machinery for turbines in such a boat, there was an increased weight of machinery of 450 tons, an increased displacement of 450 tons, and a loss of speed of 2 knots; but the design of the boat, as submitted, had certain points to recommend it, for, in addition to the absence of funnels, there would be a very much greater radius of action. Assuming, for instance, that the "Penelope" had a radius of action with full fuel supply of 4,000 knots, if fitted with Diesel machinery, that radius of action would be increased three times, say, to 12,000 knots. In face of this increased radius of action the loss of two knots in speed would be of little importance to a ship designed primarily for the destruction of enemy ships, and the entire absence of smoke and consequently the absence of funnels would render her almost invisible to hostile cruisers. Considering the serious results that followed from the cruising of the "Emden" during the war, it would be appalling to think what might be effected by such a Diesel engine cruiser being able to keep at sea for months without having to rebunker.

THE RIGHT HON. THE EARL OF BIRKENHEAD said that he would be able to add very little to the two exhaustive speeches to which they had just listened. He was not himself equipped with the necessary technical information—as most of those present were—to make it possible for him to follow everything that was said by the lecturer, but the latter had expressed himself with so much lucidity and plainness that even he (the speaker) was able to follow without very great difficulty most of the points, and he was very grateful to Sir Fortescue Flannery for having dealt in so intelligible a manner with a very technical subject.

He had been particularly interested in Sir Fortescue Flannery's revelation of the fact that the Chairman's active association with a subject so important was of such long standing. It was, indeed, a very remarkable circumstance and one eloquent of the many great services which Lord Bearsted had rendered to the community, that in this particular matter he saw so far ahead of his day and generation.

The explanations which had been given to them in the lecture and in the speech of Lord Bearsted made him wonder how any steam-driven ship had the effrontery to set foot, if he might so express it, upon any ocean in the world! He confessed that he saw very few grounds for disputing the expectation expressed by both speakers that in the near future they would witness the entire disappearance of steam propelled vessels from the seas. It was a matter of interest and not without domestic and industrial importance to reflect what the effect of a change so momentous must be upon the coal interest, and employment in that interest in this country, but such calculations would carry him too far from the immediate subject for which they were assembled on that occasion. He could not, however, doubt from the arguments which had been used by both speakers and from the convincing reasons with which they had supported their opinions, that within a time, which relatively to the lifetime of a navy must be pronounced as very short, oil would have replaced steam in all the battleships in most of the great navies of the world.

To be a pioneer in anything non-criminal in character was a distinction, and they must certainly accord to Lord Bearsted their appreciation of the decisive originality which he had shown in many other branches of life, and which had deservedly, when applied to his own private affairs, made him the master of that fortune so much of which he had generously devoted to public purposes.

HIS EXCELLENCY THE JAPANESE AMBASSADOR said he had listened with great pleasure to Sir Fortescue Flannery's paper and also to the interesting remarks of the Chairman. He was unable to add anything useful on the subject, but he wished to be allowed to say that he attended with great pleasure that afternoon because the lecturer and the Chairman were both intimately connected with the affairs of his own country. The lecturer had told him that 45 years ago he had built one of Japan's first battleships, which made a glorious name for herself in their struggles in their own waters. They in Japan had considered her a very big battleship at that time, though the audience would smile to think she was only a ship of about 4,000 tons. Since that time enormous changes had taken place. Sir Fortescue Flannery had now given him to understand there would be another great change in the near future, and Japan would, no doubt, take a very great interest in this question.

With regard to the Chairman, he had taken a prominent part 30 years ago, when comparatively few people knew much about Japan, in assisting and in persuading his friends in the City of London to assist his country by the loan of money. Japan would now look forward to having assistance in the way of the supply of oil which, he was quite sure, after listening to the remarks of the Lecturer and the Chairman, they would require in large quantities.

ENGINEER-VICE-ADMIRAL SIR ROBERT DIXON, K.C.B. (Engineer-in-Chief of the Fleet), said in the first place he would like to congratulate Sir Fortescue Flannery on his very interesting paper, which showed that depth of vision which was so necessary in dealing with engineering problems. Perhaps of all engineering problems, the development of the Diesel engine was one of the most difficult. Although a great deal of work had been done in the last four or five years in the way of that development, there was still much to be done before they could obtain those high powers which were necessary for a fast cruiser.

In considering the development of the Diesel engine from the Naval point of view, it was necessary to examine its disadvantages. In the first place it was in its present form a crank engine. He thought all students of the steam engine would appreciate this disadvantage. As an example, they might take the case of the steam engine where, after 30 or 40 years' development, the maximum horse power developed at a moderate speed of 120 revolutions was 15,000 on a single shaft. That was indicated horse power, not shaft horse power. Shaft horse power would be appreciably less. With a fast running reciprocating steam engine a maximum horse power of about 4,500 was obtained on a single shaft. The Diesel engine had very nearly approached, if it had not entirely reached that figure, as regards the fast running engine.

Another point was the heat and metallurgical problem. This was a very difficult problem and one on which both engineers and metallurgists were now working. He thought he might also say that it was one in which Lord Bearsted was particularly interested.

Again, the internal combustion engine was in its present form much too heavy. Neither had it the capacity of the steam engine to give full torque at low speeds. At present also it was not so reliable, for the steam engine, even when in a bad state of repair, could be relied on to continue working, whereas in a good many cases quite a trifling defect might put the oil engine out of action.

He laid particular stress on these disadvantages, because if improvements were to be made it was necessary to realise what the disadvantages were. All engineers realised that they would still have to make considerable progress before they obtained a reliable internal combustion engine on weights that could be accepted, to develop say, 20,000 horse power on a single shaft. But what appeared to be the impossible of to-day was very often the common-place of to-morrow, and it was, therefore, quite possible that in the near future such powers as he had mentioned might be obtained.

Lord Bearsted had referred to the Admiralty, perhaps in not very flattering terms, but he thought he might say that the Admiralty were pioneers in the installation of internal combustion engines on board ship. They had always taken a considerable interest in the development of the internal combustion engine, and he thought he might also say they had taken part in that development. It was unusual, however, for the Admiralty to institute research work in engineering matters.

Generally speaking, the engineering firms of the country had carried out all the research work necessary, and still did so in most of its branches. But the fast-running, light-weight, high-powered engines required for the Navy were a very different and much more difficult problem than the lower-powered slow-running and heavy engines which were fitted in the Mercantile Marine. Nowadays one could hardly expect private firms to carry out expensive investigations on Diesel engines without some prospect of orders resulting from those investigations. That had been realised by the Admiralty, for in 1917 the Admiralty instituted an engineering laboratory, and he thought he could say with confidence that that institution had already more than justified its existence by the work it had done.

In that connexion it was interesting to note the evolution of the Diesel engine. As Sir Fortescue Flannery had told them, they had started with the 4-cycle engine, and then adopted the 2-cycle engine, and quite recently there had been fitted 4-cycle double-acting engines. But if they were to get high powers on a single unit of a reasonable weight, it became more and more necessary to develop the 2-cycle double-acting engine. It was on those lines that research work was being carried out, with, he hoped, a fair prospect of success.

Whatever the future of the internal combustion engine might be, the whole development must tend to simplification in both design and working. They might remember that with the steam engine 30 or 40 years ago there were many and various complicated designs, from which what might be called the simple reciprocating engine of the present day was evolved. So that it might well be that from the many types of Diesel engine referred to by Sir Fortescue Flannery, there might be evolved a simpler and more durable form of engine than existed at present.

Lord Bearsted had referred to a cruiser of the "Penelope" type with regard to which there had been a design got out by some engine builders. He was sure the Admiralty would be very pleased to see that design and consider it, because he could say that the Admiralty was only too pleased so far as possible to pick other people's brains!

LORD BEARSTED intimated that he would be pleased to submit the design to the Admiralty.

SIR JAMES FORTESCUE FLANNERY, in replying, said he had little to add to the illuminating discussion they had listened to. He must, however, thank the audience for the extreme attention with which they had been kind enough to listen to what, after all, was a very dry dish of technical detail. If, however, the paper he had read had no other effect than eliciting the subsequent discussion, it had not been altogether without its utility, particularly in view of what Lord Bearsted had suggested and Sir Robert Dixon had accepted as to a design that would be considered by the Admiralty.

He would like to acknowledge on behalf of the mercantile section of the engineering profession the great indebtedness that engineers generally were under to the Admiralty for their establishment of the Research Department. Experiments were there carried out with that combination of purely scientific investigation and practical examination without which no advance in engineering was possible. He felt certain that if the great problem of obtaining larger power from the Diesel engine of given weight, which was the chief problem for naval ships, was ever to be solved, it would be solved very largely by the result of those scientific and practical investigations which were at present being vigorously carried out. They were all greatly indebted to the Admiralty, and particularly to Sir Robert Dixon in his capacity as Engineer-in-Chief, for the new departure, because it was a new departure as regards machinery, although it was an old departure as regards the form of ships. The establishment of that Research Department was one of the most effective and wisest expenditures of public money that had ever been incurred in connexion with the Navy or ships of other classes.

His own observations had chiefly been directed towards mercantile shipping, and in regard to mercantile shipping the problem of weight in proportion to the power developed did not arise so emphatically. What the mercantile shipowner required was economy in fuel far more so than economy in weight. He would, however, get both in the near future. As regards the Mercantile Marine, he was perfectly certain that in the near future there would be Diesel engine ships and Diesel engine ships only, except for certain special purposes.

With regard to what Lord Bearsted had stated as to designs for engines coming from Switzerland and elsewhere abroad, he would like to say that although the general ideas of the design had come from abroad the practical working out of the details in the drawing offices of British marine engineers had very greatly changed, and changed in the most practical manner, the details of those engines, and he looked forward with complete confidence to the time when in the near future Great Britain would still lead the way in the great improvements which were, he believed, near at hand and certain to be effected.

OBITUARY.

LORD BLYTH.—The Society has sustained a severe loss by the death of Lord Blyth, which took place at his London residence, 33, Portland Place, on February 8th, at the age of 83. He had been a Member for over forty years, having been elected in 1882. In 1904 he was appointed a Vice-President, and he continued to serve on the Council, with one short break, until the time of his death. In 1911 he was elected Chairman of the Colonial (now the Dominions and Colonies) Section. He took a very special interest in this branch of the Society's work, and was always ready to devote time and attention to it. On various occasions he presided over meetings of the Society and took part in the discussions. At the time when the question of purchasing the freehold of the Society's House was under consideration, Lord Blyth was appointed a member of the Premises Committee, and he contributed a hundred guineas to the Building Fund.

Son of James Blyth, of Chelmsford, Lord Blyth was born in 1841, and in 1863 he became a director of Messrs. W. and A. Gilbey, Ltd., of whose founder, Sir Walter Gilbey, he was a nephew. Previous to transferring his services to the Gilbeys, he was with another firm doing a large business in South African wines. By opening British markets to French light wines, the Budget of 1860 dealt a great blow to the popularity of Cape wines, but the Gilbeys took the bold, and as it proved fortunate, step of passing on to their customers all the benefit that accrued from the reduction of the duty by 70 per cent. "Never," it has been observed, "was there fuller illustration of the tide in the affairs of men which, taken at the flood, leads on to fortune."

Lord Blyth's public activities were many and various He became well known as a breeder and exhibitor of cattle, his herd of Jerseys at Blythswood, Essex, being among the most famous in England. Later he took up the breeding of Southdown sheep and Shire horses, and he was equally successful with these. Some twenty years ago he generously placed his home farm at the disposal

University of London, University College, Gower Street, W.C. 5.30 p.m. Mr. W. J. Perry, "The Spread of Culture."

At King's College, Strand, W.C. 5.30 p.m. Rev. R. Hanson, "Is there an a priori Religious Judgment?"

At the Institute of Historical Research, Malet Street, W.C. Sir Bernard Pares, "Contemporary Russia from 1861." (Lecture VII.)

At the Royal School of Mines, South Kensington, S.W. 5.30 p.m. Prof. C. A. Edwards, "Chemical Combination in Metallic Alloys and its Nature." (Lecture I.)

At the Middlesex Hospital Medical School, Cleveland Street, W. 5 p.m. Mr. E. C. Dodds, "Chemistry of the Internal Secretions." (Lecture VIII.)

Wednesday, March 4..Public Analysts, Society of, at the Chemical Society, Burlington House, Piccadilly, W. 8 p.m. 1. Mr. G. Van B. Gilmour, "A New Method for the Determination of Butter Fat." 2. Mr. R. C. Frederick, "The Investigation of Ventilation Conditions." 3. Messrs. R. C. Frederick and E. R. Webster, "A Simple and Self-Contained Spectroscope Lighting Unit." 4. Mr. P. K. Fröhlich, "The Carbon Error in the Quantitative Deposition of Nickel and Iron from Complex Oxalate Electrolytes."

Microscopical Society, 20, Hanover Square, W. 7.30 p.m. Meeting of Biological Section.

Oriental Studies, School of, London Institution, Finsbury Circus, E.C. 5.15 p.m. Mr. E. Richmond, "Early Moslem Architecture." (Lecture IV.)

Economics and Political Science, London School of, Houghton Street, Aldwych, W.C. 5 p.m. Mr. F. Pick, "The Principles of Design as Applied to our Cities and Towns."

Swiney Lectures, King's College, Strand, W.C. 5.30 p.m. Dr. W. T. Gordon, "The Geological History of Plants." (Lecture IV.)

Brewing, Institute of, Queen's Hotel, Burton-on-Trent. Mr. S. K. Thorpe, "Technical and Commercial Terms used in Brewing and Allied Trades."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. (Wireless Section.) 1. Mr. D. Dye, "Current Transformer Methods of producing small known voltages and currents at Radio Frequencies for Calibrating Purposes." 2 Lt.-Col. K. E. Edgworth and Lieut. G. W. N. Cobbold, "The Measurement of Frequency and Allied Quantities in Wireless Telegraphy."

Archaeological Institute, at the Society of Antiquaries, Burlington House, Piccadilly, W. 5 p.m. Mr. C. A. Bradford, "Heart Burial."

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. T. B. Wood, "The Nutrition of the Young Animal." (Lecture I.)

5.30 p.m. Mr. I. Björkhagen, "The Swedish Novel from Almquist to Strindberg." (Lecture I.)

At King's College, Strand, W.C. 5.30 p.m. Sir E. Denison Ross, "Travellers' Tales and the Kingdoms of Prester John, A.D. 1150-1550."

At St. Bartholomew's Hospital Medical School, 6. Giltspur Street, E.C. 5 p.m. Dr. J. M. D. Scott, "The Medullary Centres." (Lecture IV.)

At the Royal School of Mines, South Kensington, S.W. 5.30 p.m. Prof. C. A. Edwards, "Chemical Combination in Metallic Alloys and its Nature." (Lecture II.)

Thursday, March 5..Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Linnean Society, Burlington House, Piccadilly, W. 5 p.m.

Chemical Society, Burlington House, Piccadilly, W. 8 p.m. 1. Messrs. I. J. Faulkner and T. M. Lowry, "Studies of dynamic isomerism. Part XVII. The mutarotation of aluminium benzoylcamphor." 2. Mr. T. M. Lowry, "Studies of dynamic isomerism. Part XVIII. The mechanism of mutarotation, and of hydrolytic and prototropic change; with a criticism of Baker, Ingold and Thorpe's doctrine of non-intervention." 3. Messrs. T. M. Lowry and E. M. Richards, "Studies of dynamic isomerism. Part XIX. Experiments on the arrest of mutarotation in tetramethylglucose."

Victoria and Albert Museum, South Kensington, S.W. 6 p.m. Mr. A. L. B. Ashton, "Chinese Sculpture."

Royal Institution, Albemarle Street, W. 5.15 p.m. Sir Arthur S. Woodward, "Dinosaurs." (Lecture II.)

Child Study Society, 90, Buckingham Palace Road, S.W. 6 p.m. Mr. F. C. Richards, "Art in the Schools."

Aeronautical Society, 7, Albemarle Street, W. 5.30 p.m. Lieut.-Col. C. B. Heald, "Some Medical Aspects of Air Transport."

London County Council, at the Geffrye Museum, Kingsland Road, E. 7.30 p.m. Mr. P. A. Wells, "Marquetry, Parquetry, Inlaying and Intarsia of Furniture."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. Colonel T. F. Purvis, "The Post Office and Automatic Telephones."

Mechanical Engineers, Institution of (Glasgow Branch), at the Royal Technical College, Glasgow. 7.30 p.m. Mr. L. Pendred, "The Production of a Modern Technical Journal."

(N. Western Branch), at the Engineers' Club, Manchester. 7 p.m. Dr. W. H. Hatfield, "Recent Developments in Corrosive Resisting Steels."

University of London, University College, Gower Street, W.C. 5 p.m. Mr. G. A. Sutherland, "Auditorium Acoustics." (Lecture II.)

5.30 p.m. Prof. E. G. Gardner, "Mazzini as a Literary Critic."

At King's College, Strand, W.C. 5.30 p.m. Dr. A. R. Pastor, "Spanish Saints and Heretics." (Lecture II.) 6.30 p.m. Dr. O. Vocadlo, "Czech Civilisation." (Lecture VIII.)

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Prince D. S. Mirsky, "Russian Literature in the Second Half of the Nineteenth Century." (Lecture VII.)

Friday, March 6..Royal Institution, Albemarle Street, W. 9 p.m. Sir Arthur Keith, "Concerning the Rate of Man's Creation."

Auctioneers' and Estate Agents' Institute, 29, Lincoln's Inn Fields, W.C. 7.30 p.m. Mr. L. W. Chubb, "Commons and Rights of Way."

Philological Society, University College, Gower Street, W.C. 5.30 p.m. Mr. C. T. Onions, "Dictionary Evening."

Metals, Institute of (Local Centre), at the University, St. George's Square, Sheffield. 7.30 p.m. Mr. J. A. Lee, "The Evolution of the Furnace."

Mechanical Engineers, Institution of, (Informal Meeting). Storey's Gate, Westminster, S.W. 7 p.m. Discussion on "Pitfalls for Patentees."

(Yorkshire Branch.) Philosophical Hall, Park Row, Leeds. 7.30 p.m. Mr. H. Kelway-Bamber, "Rail Motor Cars."

(Midland Branch), in the Gas Department, Margaret Street, Birmingham. 7.30 p.m. Mr. F. L. Atkin, "The Commercial Testing of Materials."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Discussion on "The Work in the Society's Permanent Collection of H. P. Robinson and A. Horsley Hinton."

Engineers, Junior Institution of, 39, Victoria Street S.W. 7.30 p.m. Mr. E. F. Etchells, "How to Apply for a Job and How Not to do it."

Geologists' Association, University College, Gower Street, W.C. 7.30 p.m. Mr. J. J. Hartley, "The Succession and Structure of the Borrowdale Volcanic Series as developed in the area lying between the lakes of Grasmere, Windermere and Coniston."

Sanitary Institute, Town Hall, Halifax. 4 p.m. 1. Mr. J. Pollard, "The Working of the Milk and Dairies (Amendment) Act, 1922." 2. Mr. H. T. Lea, "Some Food Dangers."

University of London, at King's College, Strand, W.C. 5.30 p.m. Baron A. F. Meyendorff, "The Russian Church, Past and Present." (Lecture I.)

Saturday, March 7..Medici Society, at the Royal Society of Arts, John Street, Adelphi, W.C. 3 p.m. Miss L. Simpson, "Botticelli, a Fifteenth Century Modern."

Royal Institution, Albemarle Street, W. 3 p.m. Prof. Sir Ernest Rutherford, "The Counting of the Atoms." (Lecture II.)

London County Council, at the Horniman Museum, Forest Hill, S.E. 3.30 p.m. Miss M. A. Murray "Modern Excavations in Egypt."

JOURNAL OF THE ROYAL SOCIETY OF ARTS

No. 3772 VOL. LXXIII.

FRIDAY, MARCH 6, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

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NEXT WEEK.

WEDNESDAY, MARCH 11th, at 4.30 p.m. (Ordinary Meeting.) EMILE CAMMAERTS, " The Restoration of Belgian Towns." VISCOUNT BURNHAM, C.H., LL.D., will preside. Tea and coffee will be served in the Library at 4 p.m..

DOMINIONS AND COLONIES SECTION.

TUESDAY, FEBRUARY 24th, 1925. MAJOR-GENERAL SIR ERNEST D. SWINTON, K.B.E., C.B., D.S.O., R.E., in the Chair.

A paper on " Transport in Tropical Africa " was read by Mr. R. H. BRACKENBURY, Member, Empire Cotton Growing Corporation Sub-Committee on Transport.

The following took part in the discussion :—Rt. Hon. Sir Frederick Lugard, G.C.M.G., C.B., D.S.O., Sir Robert Hamilton, M.P., Mr. G. H. Baillie, Colonel P. H. Johnson, C.B.E., D.S.O., Managing Director, Roadless Traction, Limited, Colonel Sir Sydney D. Crookshank, K.C.M.G., C.B., C.I.E., Sir William M. Acworth, K.C.S.I., Lieut.-Colonel F. D. Hammond, C.B.E., D.S.O., Captain Frederic Shelford, M.Inst.C.E., and Major Sir Humphrey Leggett, D.S.O., R.E.

The paper and discussion will be published in a subsequent number of the *Joirnal.*

TWELFTH ORDINARY MEETING.

WEDNESDAY, 25th FEBRUARY, 1925. THE HON. SIR CHARLES A. PARSONS, K.C.B., LL.D., F.R.S., in the Chair.

The following Candidates were proposed for election as Fellows of the Society :—

Banner, Edgar Harold Walter, M.Sc., Wembley, Middlesex.
Binns, Arthur, Keighley, Yorks.

Burton, Montague, Leeds.
Davidson, John, Edinburgh.
Lockwood, Crosby, M.C., M.A., London.
Lowe, G. C. T., Liverpool.
Minnikin, George Rennison, Windermere, Westmorland.
Priestley, James Nicholl, St. Anne's on the Sea, Lancs.
Rutt, Harold Alfred, London.
Trigge, Joseph Edward, Croydon.

The following Candidates were duly elected Fellows of the Society :—

Bennett, James Henry, M.I.Mar.E., Sheffield.
Cayley, Bernard Briggs, London.
Cayley, Percy John, Croydon.
Lancaster, Thomas Alfred, Barnston, Birkenhead.
Murrell, Frank, Weston-super-Mare.
North, Robert Benson, Junr., Watford.
Paul, Robert William, M.I.E.E., London.
Rickaby, Tom Walton, London.
Sell, Donald Frank, London.
Standfield, Frank, Assoc.M.Inst. C.E., Surbiton, Surrey.
Truscott, Sir George Wyatt, Bt., London.

A paper on " The Power of Internal Combustion Engines for Motor Cars " was read by Sir Dugald Clerk, K.B.E., D.Sc., F.R.S.

The following took part in the discussion :—Lieut.-Colonel Mervyn O'Gorman, C.B., Professor W. E. Dalby, F.R.S., Viscount Falmouth, Dr. W. R. Ormandy, Mr. L. A. Legros, O.B.E., Mr. A. E. Parnacott, Mr. J. Ronca (Board of Trade), Mr. R. à-Ababrelton and Mr. A. F. Evans.

The paper and discussion will be published in a subsequent number of the *Journal.*

CANTOR LECTURE.

Monday, March 2nd, 1925; Mr. Walter C. Hancock in the Chair. Dr. Walter Rosenhain, F.R.S., Superintendent of the Department of Metallurgy and Metallurgical Chemistry, National Physical Laboratory, delivered the third and final lecture of his course, " The Inner Structure of Alloys."

On the motion of the Chairman a vote of thanks was accorded to Dr. Rosenhain for his interesting course.

The lectures will be published in the *Journal* during the Summer recess.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1925 early in May next, and they therefore invite Fellows of the Society to forward to the Secretary on or before Saturday, March 21st, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce," and has been awarded as follows in previous years :—

1864, Sir Rowland Hill, K.C.B., F.R.S.

1865, His Imperial Majesty Napoleon III.

1866, Michael Faraday, D.C.L., F.R.S.

1867, Sir W. Fothergill Cooke and Sir Charles Wheatstone, F.R.S.

1868, Sir Joseph Whitworth, LL.D., F.R.S.

1869, Baron Justus von Liebig.

1870, Vicomte Ferdinand de Lesseps, Hon. G.C.S.I.

1871, Sir Henry Cole, K.C.B.

1872, Sir Henry Bessemer, F.R.S.

1873, Michel Eugène Chevreul, For. Memb. R.S.

1874, Sir C. W. Siemens, D.C.L., F.R.S.

1875, Michel Chevalier.

1876, Sir George B. Airy, K.C.B., F.R.S.

1877, Jean Baptiste Dumas, For. Memb. R.S.

1878, Sir Wm. G. Armstrong (afterwards Lord Armstrong), C.B., D.C.L., F.R.S.

1879, Sir William Thomson (afterwards Lord Kelvin), O.M., LL.D., D.C.L., F.R.S.

1880, James Prescott Joule, LL.D., D.C.L., F.R.S.

1881, Professor August Wilhelm Hofmann, M.D., LL.D., F.R.S.

1882, Louis Pasteur.

1883, Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.

1884, Captain James Buchanan Eads.

1885, Sir Henry Doulton.

1886, Samuel Cunliffe Lister (afterwards Lord Masham).

1887, HER MAJESTY QUEEN VICTORIA.

1888, Professor Hermann Louis Helmholtz.

1889, John Percy, LL.D., F.R.S.

1890, Sir William Henry Perkin, F.R.S.

1891, Sir Frederick Abel, Bt., G.C.V.O., K.C.B., D.C.L., D.Sc., F.R.S.

1892, Thomas Alva Edison.

1893, Sir John Bennet Lawes, Bt., F.R.S., and Sir Henry Gilbert, Ph.D., F.R.S.

1894, Sir Joseph (afterwards Lord) Lister, F.R.S.

1895, Sir Isaac Lowthian Bell, Bt., F.R.S.

1896, Professor David Edward Hughes, F.R.S.

1897, George James Symons, F.R.S.

1898, Professor Robert Wilhelm Bunsen, M.D., For. Memb. R.S.

1899, Sir William Crookes, O.M., F.R.S.

1900, Henry Wilde, F.R.S.

1901, HIS MAJESTY KING EDWARD VII.

1902, Professor Alexander Graham Bell.

1903, Sir Charles Augustus Hartley, K.C.M.G.

1904, Walter Crane.

1905, Lord Rayleigh, O.M., D.C.L., Sc.D., F.R.S.

1906, Sir Joseph Wilson Swan, M.A., D.Sc., F.R.S.

1907, The Earl of Cromer, O.M., G.C.B., G.C.M.G., K.C.S.I., C.I.E.

1908, Sir James Dewar, M.A., D.Sc., LL.D., F.R.S.

1909, Sir Andrew Noble, K.C.B., D.Sc., D.C.L., F.R.S.

1910, Madame Curie.

1911, The Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., F.R.S.

1912, The Right Hon. Lord Strathcona and Mount Royal, G.C.M.G., G.C.V.O., LL.D., D.C.L., F.R.S.

1913, HIS MAJESTY KING GEORGE V.

1914, Chevalier Guglielmo Marconi, G.C.V.O., LL.D., D.Sc.

1915, Sir Joseph John Thomson, O.M., D.Sc., LL.D., F.R.S.

1916, Professor Elias Metchnikoff.

1917, Orville Wright.

1918, Sir Richard Tetley Glazebrook, C.B., Sc.D., F.R.S.

1919, Sir Oliver Joseph Lodge, D.Sc., LL.D., F.R.S.

1920, Professor Albert Abraham Michelson, For. Memb. R.S.

1921, Professor John Ambrose Fleming, D.Sc., F.R.S.

1922, Sir Dugald Clerk, K.B.E., D.Sc., LL.D., F.R.S.

1923, Major-General Sir David Bruce, K.C.B., D.Sc., LL.D., F.R.C.P., F.R.S., and Colonel Sir Ronald Ross, K.C.B., K.C.M.G., D.Sc., LL.D., M.D., F.R.C.S., F.R.S.

1924, H.R.H. THE PRINCE OF WALES, K.G.

PROCEEDINGS OF THE SOCIETY.

EIGHTH ORDINARY MEETING.

WEDNESDAY, JANUARY 28TH, 1925.

SIR GEORGE HOPWOOD HUME, M.P., L.C.C., in the Chair.

THE CHAIRMAN said that the original invitation for designs for a County Hall resulted in something like ninety-nine entries, the work of 152 architects.. The reconstruction of the river wall was begun in January, 1909, and the King laid the foundation stone of the building in 1912. The constructional work was seriously delayed owing to the war, when all operations were stopped, and the unfinished building was taken over by the Government for the Department of Food Control. The result of all this was that the original estimates for the cost of the hall were altogether upset, and the figure had swollen to an immense extent, owing to the work having to be commenced again when prices were extremely high. The constructional work was not resumed until 1919, and the building was formally opened by the King in 1922. A paper had already been read by Mr. Ralph Knott, the architect, describing the architectural details of the building, and there had been other papers read before the Royal Institution of British Architects and the Institution of Heating and Ventilating Engineers. The paper to be read that evening went a stage further and dealt with the electrical equipment, detailed particulars of which might be multiplied very largely indeed. The automatic telephone system could occupy an hour by itself. Automatic telephones were now being very largely developed. The Post Office was taking the matter up with much seriousness and immense improvements had been effected. An expenditure of millions of pounds on the development of this system, in London and the country, was contemplated, and it would be extremely interesting to have a few words on the application of this system to so large a hall as that of the London County Council. Another interesting point was that the building contained laboratories in which the Medical Officer of Health carried out experiments, but he did not think Mr. Baker would deal with that very fully. He would also like to say a word about the lecturer. Mr. Baker had been with the London County Council for nearly twenty years. He was one of those officers who made everything go smoothly, although himself remaining in the background. When the question arose as to what should be done with regard to electrical equipment at the County Hall, the Chief Engineer, Mr. G. W. Humphreys, who was just at that time succeeding Sir Maurice Fitzmaurice, consulted the latter gentleman as to whether the Council should carry out this work itself or call in someone from outside, and Sir Maurice Fitzmaurice said: "We have a man in the Council's service who is quite competent to carry out the work." He did carry it out, and he was there that evening to describe how it was done.

The paper read was:—

THE ELECTRICAL EQUIPMENT OF THE LONDON COUNTY HALL.

By CHARLES A. BAKER, M.I.E.E., Assistant Engineer of the London County Council.

The building, now well known to all the London members, is situated on the River Thames near Westminster Bridge.

The site—including 2½ acres of reclaimed foreshore—measures about 6½ acres and in 1906 international invitations were issued for competitive designs.

o an appropriate building; that sent in by Mr. Ralph Knott was eventually selected.

The building now erected consists of 9 storeys, including a basement and sub-basement, the roof ridge being about 130 feet above the foundation; the Council Chamber is 55 feet high, the rooms generally on the 1st floor 16 feet, and the offices throughout about 11½ to 12 feet from floor to ceiling; it provides accommodation for 200 members and a staff of 2,270; the northern extension —of which the foundations are under construction—will afford further staff accommodation for about 600. The Medical Officer's Department includes various laboratories. There are also luncheon rooms, kitchens, cold storage, larders and considerable storage accommodation for records, etc., in the basement and sub-basement.

During the construction of the building a temporary supply of electrical energy was taken at 460 volts, d.c., for lighting and to operate the following plant:—

8— 5 ton Derricks with 20 h.p. motors.
1—10 „ Ditto 30 ditto.
2— 5 „ Travellers with 20 and 12 h.p. motors.
1— 8 „ „ twin jib with 20, 20 and 12 h.p. motors.
3— 3 „ Hoists with 30 h.p. motors.

22 motors, totalling 166 h.p., were used for crushers, mixers, barrow hoists, pumps, air compressors, etc; a total connected power load of about 566 h.p. The travelling cranes were supplied through armoured cables with plug boxes fixed at intervals to which cab tyre trailing cables were connected.

One of the earliest questions that arose when dealing with the permanent equipment of the building was that of the source of electrical supply; whether to generate it or to purchase it. Under the first heading numerous methods present themselves, under the second there are alternative tariffs one or other of which according to circumstances may be the more advantageous.

Some approximation of the load and load factor must be calculated; a building used largely for office accommodation does not at first sight appear to offer an attractive load factor but there is a lot of work to be done after office hours in cleaning such a building for which purpose ample illumination is necessary. It was eventually recommended to purchase the whole of the electrical energy from the London Electric Supply Corporation, Ltd., in whose area of supply alone the building is situated and for safety against possible failure of supply the Company agreed to bring in a main from an independent generating station to provide approximately 10 per cent. of the energy for lighting, and this was effected by arrangement with the Westminster Electric Supply Corporation, Ltd. The supplies are thus obtained from one generating station at Deptford (about 4½ miles east), and another at St. John's Wood (about 3 miles north-west).

Accommodation for a 10,000 volt sub-station measuring about 30 feet x 30

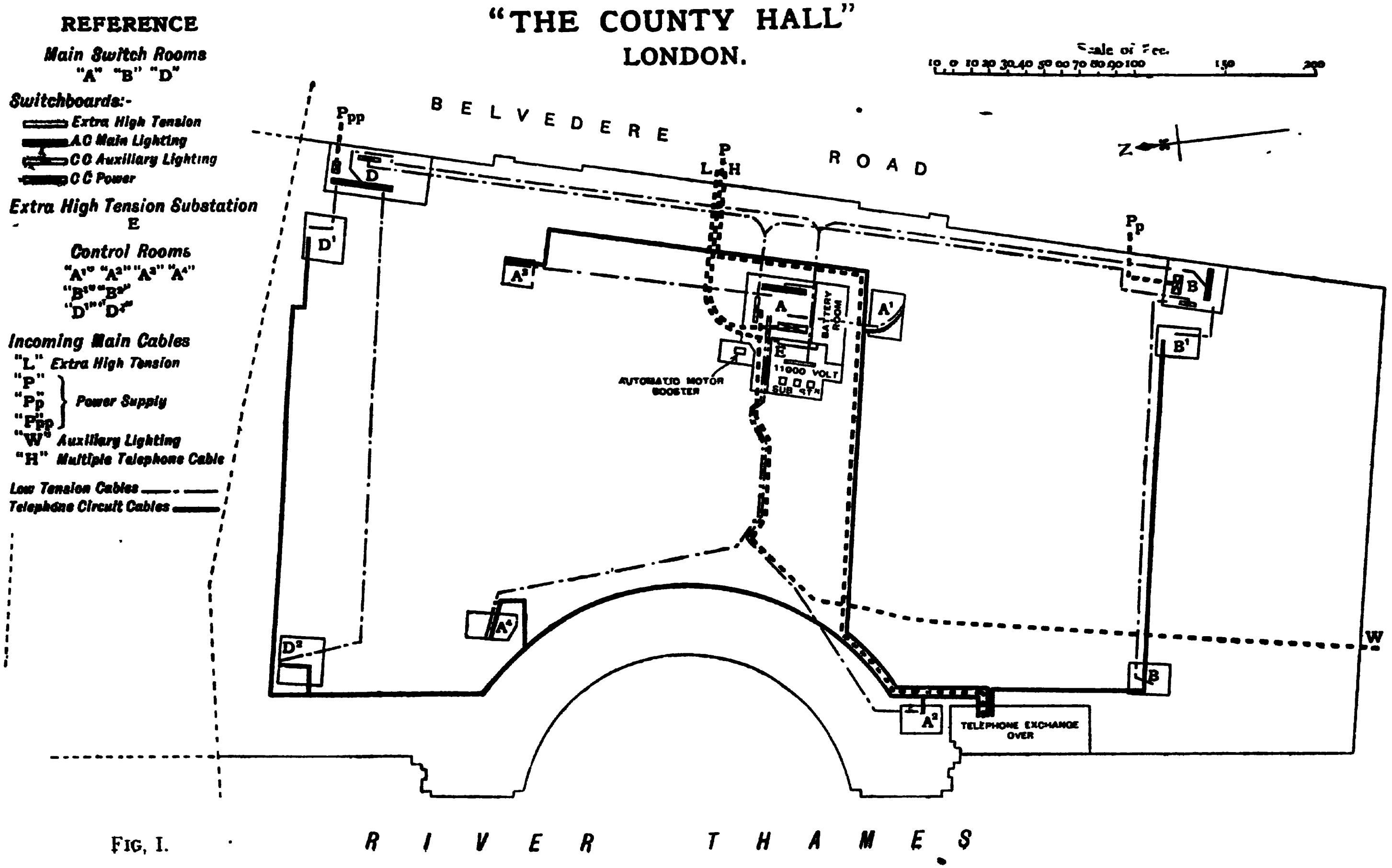

"THE COUNTY HALL"
LONDON.
REFERENCE
Main Switch Rooms
"A" "B" "D"
Switchboards:-
Extra High Tension
A.C Main Lighting
C.C Auxiliary Lighting
C.C Power
Extra High Tension Substation
E
Control Rooms
"A¹" "A²" "A³" "A⁴"
"B¹" "B²"
"D¹" "D²"
Incoming Main Cables
"L" Extra High Tension
"P"
"Pp"
"Ppp"
Power Supply
"W" Auxiliary Lighting
"H" Multiple Telephone Cable
Low Tension Cables
Telephone Circuit Cables
Scale of Feet
10 0 10 20 30 40 50 60 70 80 90 100 150 200
Z
BELVEDERE ROAD
Ppp
D
D¹
D²
P
L H
Pp
A³
A
BATTERY ROOM
A¹
E
11000 VOLT SUB STN
AUTOMATIC MOTOR BOOSTER
B
B¹
A⁴
A²
TELEPHONE EXCHANGE OVER
W
RIVER THAMES

FIG. I.

feet, shown at " E " Fig. 1, was provided in the sub-basement in which three single phase transformers each of 250 kilowatts capacity are located.

The extra high tension mains are brought in through three inch cast-iron pipes. The supply is usually taken through cables running direct from Deptford, but should these fail the supply can be given through either of two alternative mains.

The extra high tension equipment is located in cubicles formed against the sub-station wall, enclosed with steel frames and doors. The bus bars consist of 1½′ x ¼′ copper insulated on porcelain supports, air break isolating switches and oil break circuit switches being arranged in separate cubicles. The oil switches are operated by levers which pass across the floor in covered ducts to the operating handles fitted on the Control Panel.

The secondary sides of the transformers are wound for 420 volts with middle point connection to enable the distribution to be carried out on the three wire system. The low tension cables run direct to the main switchrooms " A.B. and D." (Fig. 1.) The lighting of the building generally is taken from this supply.

The power supply is connected to the London Electric Supply Corporation's D.C. mains at 460 volts with three services brought into the building at the three switchrooms above referred to.

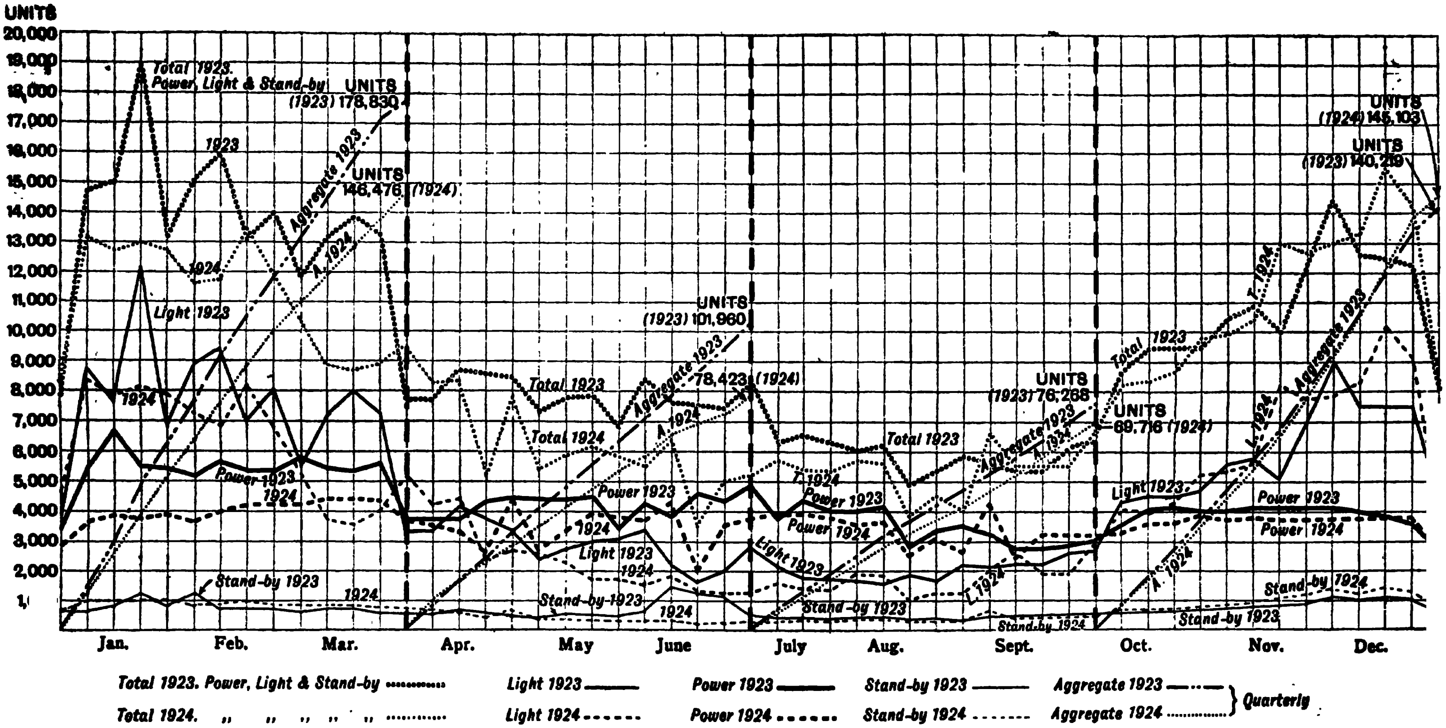
The auxiliary supply of the Westminster Company is direct current at 400 volts; a triple concentric main of 0.5 x 0.5 x 0.25 sq. in. section is laid over Westminster Bridge and connected to the Company's mains near the House of Commons. To bring this voltage up to the a.c. figure of 420 volts and to allow for loss of pressure at this somewhat remote point from the Company's normal area of supply a motor booster is used. It is wound to boost each side from 10 up to 15 volts with a full load output of 175 amperes. It comes automatically into circuit when the current rises to 25 amperes (with adjustment to suit conditions which may vary from time to time), as the load diminishes the contactors again operate in the reverse order, cutting the booster out of circuit and closing the main supply circuit direct on to the switchboard.

The main switchrooms, A. B. and D., are in the sub-basement. Substantial wrought iron frames are built into the floor to carry the slate panels on which the switchgear, fuses and measuring instruments are mounted.

In each room there are three switchboards to control respectively :—

the A.C. supply for lighting.
the D.C. auxiliary ditto.
the D.C. power supply.

The switchboards dealing with the A.C. supply are designed (on a basis of 150 amperes per sq. in. of contact area) to carry 500 amperes and the branches to the distribution points (control rooms) for 100 amperes with throw-over switches to facilitate balancing the load on each side of the three wire system. The Boards were tested with 2,000 volts A.C. between current carrying parts



Note:- For "Aggregate" curves multiply scale of units by 10

FIG. 11.

and the framework. Recording instruments can be connected in any circuit to check the rate or duration of consumption.

The cable dividing boxes for the incoming and outgoing mains are attached to the switchboard framework; bare copper rod is used to connect the cable ends to the switchboard terminals.

The boards controlling the auxiliary supply are of similar pattern on a smaller scale. No subsidiary switches are used between the main circuit switches and the switches actually controlling the lamps.

The power boards are ironclad throughout with interlocked doors.

Curves showing the monthly consumption for 1923 and the comparable consumption for 1924 are given on Fig. II.

The main cables are paper insulated, triple core, drawn through 2½ nch wrought iron pipes to the respective control rooms. The wrought iron pipes are carried on racks attached to the steel joists of the sub-basement ceiling, thence up through vertical chases which were arranged when the building was under construction. The importance of laying out the runs of the main cables at an early stage cannot be too strongly urged. Large sums of money are involved in cutting away brick and stonework if this is not done.

The cables in the vertical ducts are armoured with galvanised steel wires—the horizontal cables are generally lead covered only. At the termination of the vertical runs the cables are clipped by a grip designed to sit in the end of the 2½ in. wrought iron pipe and bored internally to accurately fit the different sizes of cables used; for cables rising to the upper floors the pipes are cut and clips fixed at intermediate floors to carry part of the weight and thus relieve the strain at the top.

The three core cables used for the lighting circuits terminate at a dividing box in one or other of the control rooms, one side of the three-wire system being used on one floor and the other side of the system continued to the control room on the floor above; in this way a reasonably even balance has been effected. By using the three wire system of distribution to the control rooms about £8,000 was saved in the copper conductors necessary to carry the energy.

If the copper losses were taken as the basis of the exact sizes of all the mains in a building of this description a large number of comparatively short lengths of different size cables would need to be made; it was found more economical to restrict the sizes to three, viz.—0.2, 0.12, and 0.075 sq. in. for the outers with neutrals of 0.12, 0.075 and 0.04 sq. in. respectively; this it will be seen necessitated actually setting up the machines for manufacturing only 4 sizes of copper cores.

From the dividing boxes V.I.R. cables are taken to the sub-distribution boards.

Eight control rooms have been established on each floor, occupying, as far as circumstances permitted, identical sites on the plan of each floor to facilitate the layout of the chases for the vertical mains; in these rooms 165 sub-distribution centres are constructed, from the fuses of which the circuits are looped to lamps and apparatus in the offices and corridors. About 240 miles of circuit wires are carried through steel conduits run principally in the air ducts (which form part of the corridors), thence into the rooms, the conduit terminating in a circular cast iron box 5 in. diameter, with internal fitting; from this box a pendant is fixed and four holes round the side enable additional pendants to be run if wanted for any purpose.

Behind the skirting boards a steel trough 2½' x ½' has been run, with direct connection to the conduit system, to facilitate modification of any circuits in the rooms without causing serious disfigurement to the decorations.

Throughout the offices a system of general illumination has been provided giving about three foot candles on the working plane. The first floor fittings were specially designed by the Architect; the Council Chamber is lighted from four fittings, each of which contains ten 300 watt gas filled lamps, with a resulting illumination on the tables and desks of about 5.5 foot candles.

Numerous samples of glass, to use in these fittings, were tested; ultimately, a lightly obscured sample was approved through which the glowing filaments of the lamps could not be seen; the obscuration amounted to only 9 per cent.

The offices on the 6th and 7th floors are provided with white opal reflectors, 14 inches diameter and 7 inches deep, open at the top to give ample ventilation. The offices on the other floors are fitted with semi-indirect lighting, the bowls being as translucent as possible without permitting the lamp filaments to be visible. Samples of glass were tested in large quantities, and the majority of those finally approved cut off 15% of the direct illuminating rays.

The corridors are lighted from the top with small lamps and frosted globes cutting off only 6½% of the light; there are 622 of these fittings.

The approximate number of lamps in the building is 6,024, a connected load of 622 kilowatts controlled by rather over 5,000 tumbler switches (these are mounted on grids fixed inside the c.i. boxes with collars to secure the cover plates). Approximately 98 miles of conduit, 4 miles of steel troughing behind skirting boards, 25,000 c.i. inspection and junction boxes and 10,000 yards of flexible cord insulated with pure rubber have been used on the work.

Connected to the power supply—460 volts, d.c.,—are 8 passenger lifts and 13 goods and service lifts. The latter are all automatic; of the former one is automatic, three are controlled by car switch only, whilst four can be worked either as automatic or under car switch control as desired according to the conditions of traffic; the morning, mid-day, and evening traffic respectively is exceedingly heavy. Two of the large lifts are fitted with motors of 40 h.p. running at 450/650 r.p.m., to carry 28 passengers at a lifting speed of 250 feet per minute.

All the lift rooms (except in the case of some of the service lifts) can be reached from the inside of the building, a matter to which the author attaches considerable importance from the point of view of maintenance. A trap door is provided to allow the largest item composing part of the lift gear to be lowered to the floor beneath and a central girder is fixed at the ceiling level to which blocks and tackle can be attached; levers are provided to enable a man single-handed to release the brakes gradually to bring the cage to one of the landings in case of failure of the motive power.

In addition there are 58 electric motors used to drive ventilating and plenum fans, boiler and circulating pumps, refrigerating plant and to operate pneumatic tubes, the aggregate being 442 h.p., exclusive of minor apparatus such as floor polishers, vacuum sweepers, potato peelers, knife cleaners, envelope openers, etc.

The electric clocks, fitted generally in each room throughout the building, number 805; these are driven off eight master clocks regulated to approximately three seconds per month; half-minute impulses are stepped at intervals of a few seconds between the 8 circuits. The duration of the impulse is one ninth of a second and the circuit current three tenths of an ampere with eight-tenths of a volt per dial. A condenser is fitted in each master clock to relieve any tendency to sparking and non-inductive shunts are provided to the electro-magnets operating the dials; each circuit is protected by a thermal cut-out designed to safeguard the battery in case of a master clock stopping in closed contact or a short circuit occurring in the wiring system.

Two sets of small accumulators are used for supplying energy to the clock circuits.

Should a master clock cease to function for any reason, its circuit can be switched over to a relay, inserted in one of the other master clock circuits, and the series of clocks controlled by the faulty master clock again energised without delay. The system is so well regulated that it has not been considered necessary to make any application for connection to the Greenwich time signal.

The diameters of dials are generally 8 in., 10 in. and 12 in.; but quite a number of antique cases which served to house mechanical clocks in the offices previously occupied by the Council and its predecessor, the Metropolitan Board of Works, have been utilised and fitted with electrical movements.

Distant thermometers are fitted in different parts of the building indicating electrically, in the heating control room, both the wet and dry bulb temperatures.

The automatic telephone equipment enables the occupant of any room to get into communication immediately with an occupant in any other room in the building; the same instrument serves for calls, via the Hop Exchange, to the outside world, but that traffic passes through a manually operated board.

There are about 640 extensions on the automatic system, it is capable of enlargement up to 900; the value of automatic telephones in a large building cannot be overrated; a private telephone directory is essential and must be kept up-to-date; for one reason or another alteration in the occupation of rooms is of frequent occurrence. In the absence of such a telephone system minor systems of domestic telephones and electric bells between heads of departments and their subordinates come into existence, increase and multiply, costing a lot of money to maintain and serving no further purpose when any change of occupancy of the rooms occurs; the automatic system throughout the building avoids all this.

A record of one normal week's internal telephone communications over the system is as follows:—Monday, 2,744; Tuesday, 3,030; Wednesday, 3,024; Thursday, 3,193; Friday, 3,053; Saturday and Sunday, 1,445; total, 16,489, approximately one message per occupant per diem.

A system of supervisory alarms is provided to indicate any trouble should it arise and what part of the apparatus is affected. There are two ringing rotary-converters one or other of which is always in operation. The current for working the system is derived from duplicate sets of 25 accumulators of 280 ampere hour capacity with a 65 volt motor generator for charging them. A general view of the front of the automatic switchgear and the charging motor generator will be shown by a lantern slide.

Connected to the manual switchboard there are 43 exchange lines and 23 tie-lines running to outside offices with which the Council needs to be frequently in communication. After office hours the manual board is closed down, certain lines are switched over to " fire call " instruments on each floor which the watchman can make use of, should necessity arise, and another switch puts any incoming calls on to a sub-switchboard, where a night watchman is always in attendance.

The telephone switchroom is in the basement; the multiple cable is brought in from Belvedere Road and the internal mains run up the vertical chases already described; the wiring to instruments is carried out through steel conduits to the various rooms.

Only two small sets of domestic telephones have crept into existence, one in connexion with the dictation of correspondence and the other between the canteen and kitchen.

Somewhat special to the work carried on at the County Hall are the " Division Bells" and the " Annunciators."

The bells form an important part in the method of settling any item of dispute on the Council's agenda; when a division is called the bells are set ringing and need to be of such a character that members will clearly understand their purpose, as distinct from any other bells in use in any part of the building. This is effected by mounting two gongs of different tones on either side of a striking hammer; when the circuit is closed the hammer hits one gong and when the circuit is broken it rebounds against the other. There are 69 of these bells, wound to 200 ohms and arranged in five main circuits, with a small motor driven controller operating the make and break of the individual circuits.

in sequence, they are run off a set of accumulators located in a room adjoining the main switchroom.

The "annunciators," of which there are ten, in the lobbies, library and principal rooms, used by the members on the first floor, with two test instruments in the transmitter room, are intended to indicate what matter is under discussion or who is speaking in the Council Chamber, so that members in the Library or elsewhere may be kept informed of what is happening. The Clerk of the Council controls the service by writing on a slip of paper any item which he wishes to appear, the slip of paper is inserted in a carrier, which in turn is placed in the pneumatic tube and immediately conveyed to the operator in the transmitter room. There the wording—for example: "Education Committee Report"—is rapidly set up in special type, which is fixed in a frame so that it passes under seven electric contacts, any of these, making contact with the raised type, close circuits through electro-magnets on the receivers which actuate ink rollers arranged to press against a strip of moving paper, and so form printed letters 1½' high that can be read from any part of the room in which the receiver is fixed. An example of the printing is shown on one of the lantern slides; how the seven contacts come into operation can be easily followed. A message having reached the transmitter room appears on the receiving instruments about 1¼ minutes later.

Protection against lightning does not come strictly within the title of the paper, but as the system adopted is to some extent novel it may perhaps be referred to. Sixty-six prominent parts of the roof are protected by copper rods, from which short lengths of copper tape are run and riveted to the nearest joist forming part of the steel framework of the building—about 8,000 tons of steel have been used in this framework. Before deciding to dispense with the usual copper tapes and earth plates a series of tests were made. One end of a wire hawser was immersed in the river and the other end supported at roof level by a derrick and insulated. A number of measurements showed a resistance of less than 0.5 ohm between the hawser and the roof joists.

The question of electrical cooking is now before the Kitchen Committee; nothing of any importance has been done in that way.

The work described was carried out under the responsibility of the Chief Engineer of the London County Council, Mr. G. W. Humphreys, C.B.E. The author is particularly indebted to his assistants, Mr. A. H. Sears and Mr. H. G. Witham, for their generous efforts in carrying through the work.

DISCUSSION.

Mr. H. D. **Wilkinson** said that he had been especially interested in the duplication of supply which had been arranged between the London and the Westminster Supply Corporations. It was always—as he knew from experience in theatre work—a matter of somewhat lengthy negotiation to get these companies to give a stand-by supply, especially when, as in theatre work, there was required a change-over switch of considerable magnitude. He had been interested also in the description of the automatic telephone, and especially in the fact that permission was given by the Post Office for connexion with the outside world. It stood to Mr. Baker's credit that he should have overcome the inertia of the G.P.O. in providing such great facilities for the important business which occupied the building in question. He hoped, as Mr. Baker had very properly said, that this might be the means of leading the Post Office to take a more lenient view when other people of less importance approached it. He (the speaker) had just returned from the United States, where he had been greatly struck with the telephone facilities. There they never seemed to have the least trouble to get a number. In many of the sky-scraper buildings the automatic telephones were installed. A telephone appeared to be on every man's table, and almost every second man had a telephone to his ear. He noticed that Sir Oliver Lodge had been saying that although wireless was a most wonderful thing, yet to his mind the simple iron diaphragm responding in the telephone receiver to electrical impulses and transmitting the impulses in the form of sound was even more wonderful. That opinion, from a scientist of such high standing, opened up a remarkable line of thought. The telephone was an absolute necessity to business life, and arrangements such as Mr. Baker had made to get through to the right party quickly and with certainty were of marked utility.

Mr. F. HOPE-JONES said that he was one of those who could testify to the great competence of the author in his particular department. It was most interesting to him to hear that it had ever been considered that outside experts should be called in in the early stages of this great scheme, but he was particularly pleased at the outcome of that brief consultation which resulted in Mr. Baker being given charge of the work.

Mr. H. J. GREENWOOD (late Chairman, Establishment Committee, London County Council) referred to the close association he had with Mr. Baker for nearly two years while the work which he had so admirably described in the paper was proceeding. The work was amazingly complex, but through it all Mr. Baker never seemed to lose sight of that clear and direct purpose which had characterised his success in all his work, and at the same time no detail, however small, seemed to escape him. Throughout the whole of their association, which was a daily one for many months, the speaker was more and more amazed and more and more thankful as a member of the London County Council that that body had such an officer in charge of this great work. He thought that the Council might well look back with pride on the work done in this respect.

MR. BAKER, in reply to a member of the audience, who asked for some particulars about the ventilating arrangements, said that these were fully described by his colleague, Mr. Moodie, in a paper which he read jointly with Mr. Grenville before the Institution of Heating and Ventilating Engineers. The general scheme was the Plenum system for the Council Chamber, the large committee rooms, and the sub-basement, and extract fans in the Council Chamber with outlet over the roof. The air for the Council was specially purified, cleansed, washed, and warmed. It was altogether a most complete system, reflecting the greatest credit on Mr. Moodie for all the trouble he had taken in designing it. It was probably a superior arrangement to that which existed in the House of Commons.

THE SECRETARY suggested that Mr. Baker might usefully give some further particulars about the automatic telephone system. The system was comparatively so new that many might welcome an explanation.

Mr. Baker said that in automatic telephony the caller used an ordinary standard telephone, by the side of which was a dial with ten finger-holes numbered 1 to 0. In the first place, he removed the receiver from its hook, and then if, say, the number he wanted was 357, he would put his finger in the hole marked 3, turn the dial round to its stop, and then release it, when it would speedily return to its original position. The speed at which the dial flew back was governed by a little adjustable two-ball governor, and during this return movement three contacts would be made in the case of the three digit, five contacts in the case of the five, and so on. It was this return motion on which everything depended. The three contacts made on the backward journey gave three impulses on the hundreds panel. Then the figure 5 was dialled in the same way, when the contacts, owing to the first figure having been dialled, were transferred to the next panel, which gave the tens figures, and the same thing took place with the final figure, the 7. The whole operation should not last longer than 10 or 12 seconds, and it could be repeated as often as required. The main difficulty and the real source of trouble with automatic telephony was any accumulation of dust in the telephone switch room.

Mr. H. R. Saxty was sure that it would be a great surprise to many laymen to know the immense extent of the work which pertained to the electrical equipment of the County Hall. He would have liked a few more details with regard to the annunciator, but he supposed it was difficult to make this intelligible without a very long description.

A Member of the Audience asked whether, having got his lightning conductors attached to the steel joists of the building, Mr. Baker found it necessary to test periodically, and, if so, whether he had any arrangement for so doing.

Mr. Baker said that it was distinctly desirable to test anything of that kind periodically. He was enabled to do this by means of conductors fixed to the chimney shaft for the boilers. That chimney shaft was put up before the steel work of the building was arranged, and he had to run copper tapes from the top of the chimney shaft to the bottom and connect to the earth there. This served his purpose when he wanted to test the other rods.

Mr. R. A-Ababrelton said that he was glad to have this last explanation, because, understanding that the County Hall stood on a thick bed of concrete, he had been puzzled to think how the author managed to get to earth.

Mr. Baker said that the block of concrete was waterlogged and to some extent porous. The lift shafts, which were numerous, were each fitted with metal guides, and it was desirable in some cases to scratch a hole in the concrete to put the foot of the guide into it. As soon as one did so, water began to come up through the concrete block, and in order to prevent this continuing, the footings for these lift guides had to be very carefully asphalted. That was one of the reasons why the architects objected to his making any holes in the concrete block. In addition to the steel framework of the building standing on the waterlogged concrete block, he would point out that there were a number of water mains, gas-mains, and pipes bringing in electric mains, which were hung on to the steel joists of the building and went out to the streets beyond. These all helped to bring down the resistance of the steel joist connection to earth to such a low figure that he felt quite confident in using the arrangement he had described. Apart from that, if any of the lightning conductors were operative they at once had a very big network of distribution amongst the large mass of steel joists. He thought that the building was quite safe from this point of view.

In further reply to a member of the audience, who asked how the iron troughing was used for making circuits, Mr. Baker said that the iron troughing consisted of U-shaped sheet steel with a cover which sprang on to it. This was laid round under the skirting boards and joined up with the conduit system, so that it was possible to get wires easily arranged for lamp connections in any part of a room, and a change in position of the furniture need not cause any great disturbance. One was enabled with this arrangement to go more or less all round the room, and, generally speaking, to get to any point in the room with additional flexible wires so as to meet individual requirements.

Asked whether he had considered the possibility of bare copper conductors, Mr. Baker said that this was scarcely possible in the comparatively small space allotted to him. If he had had plenty of room he would have been pleased to have used bare copper main cables, but in the necessarily restricted space one must have insulated cable. The advantages of bare copper would, of course, be numerous, but one would have to guard against interference: in picking out the different control rooms he thought at first that he was going to have more than sufficient space, but then other people came and took possession of this or that position for purposes of a different character, such as sanitary or water pipes, &c.

A MEMBER OF THE AUDIENCE asked whether he understood, with regard to the general lighting, that the general illumination was about 5½-foot candles, or was this only in the Council Chamber?

Mr. BAKER said that the illumination of 5½-foot candles mentioned in the paper referred specially to the Council Chamber. In the offices it was in the neighbourhood of 2½ to 3-foot candles. If any complaint were made about the lighting, and it was measured and found to exceed two-foot candles, he would be inclined to say that that was sufficient. In specially fine work a higher standard of illumination might be desirable, but anything about 3-foot candles was quite comfortable light for ordinary work.

THE CHAIRMAN (Sir George Hume) said that many interesting questions had been put in the course of the discussion, and he felt sure that all those present were extremely grateful to the lecturer that evening for the pains he had taken to put on record the work done in the County Hall. The great novelty to most people was the installation of the automatic telephone. He would advise everyone to see, if they had the opportunity, an automatic telephone exchange at work. One thing which was driven home to his mind was the immense amount of foresight which was needed when a huge building of this sort was to be dealt with, and when all sorts of unexexpected requirements had to be met. Mr. Baker had brought this out extremely well, and he was sure those present would desire to accord him a hearty vote of thanks.

The vote of thanks was carried unanimously.

DEVELOPMENT OF FRENCH WATER-POWER RESOURCES.

France takes third place amongst the countries of the world as regards her water-power resources, which are exceeded only by those of the United States and Canada. The total power available is estimated at eight or nine million h.p., of which prior to the war only 900,000 h.p. had actually been utilised (almost entirely concentrated in the Alps or Savoy district). With the ever-increasing demand for electrical energy, both for industrial and agricultural uses, as well as for domestic requirements, the development of these natural resources has become of the greatest importance, and since 1916 considerable results have been achieved. According to the annual Report of the Commercial Counsellor to H.M. Embassy in Paris, the present power is stated to have reached 2.7 millions, and by 1926 it is expected that the total power in France will be further increased by 300,000 h.p. It is estimated that the saving of coal effected by the utilisation of one million h.p. may be reckoned as the equivalent of eight million tons of coal per annum.

The schemes for the utilisation of the rivers of France are distributed over four principal areas—(1) the Alps, Rhône and Jura; (2) the Pyrenees; (3) the Massif Central; (4) the Rhine, the Vosges and the Moselle.

The Alps take an outstanding position in France as regards water-power development; it has been said that every water-course in the South-East of France has been explored and a water-power valuation placed upon it. The Department of the Isère takes first place as regards the turning to account of its rivers, and utilises two-fifths of the present total production of France, although the River Isère and its tributary the Drac have only been partially developed. Savoy closely follows, and in its principal industrial centre, the district of the Arev, six stations are installed with a productive capacity of 60,000 h.p. In the valley of the Arc below Modane, twenty-three stations are in operation (or in course of being put into operation) capable of producing 160,000 h.p., which includes the stations at Avrieux (20,000 h.p.), Prémont, Sainte-Marie-de-Cuines (12,000 h.p. each), Praz, Saussaz, Pontamafrey (from 15 to 20,000 h.p.). In the valley of the Romanche within a radius of 12½ miles seventeen stations produce a force of 140,000 h.p., and include the large station at Rioupéroux (28,000 h.p.) the property of the *Aciéries et Forges de Firminy.* On the upper reaches of the Isère, in Tarentaise, close to Saint-Foy, is the powerful station of Viclaire (40,000 h.p.) and other stations producing a total of 60,000 h.p. are found within the region. At the junction of the Isère and the Arly, stations exist or are under construction which will eventually provide the works at Ugine with a total power of 60,000 h.p. The Bréda, another tributary of the Isère, is for its length the most utilised waterway of the French Alps; twenty-five stations are in operation within a distance of twenty miles. The Drac is as yet only partially developed, but it possesses ten stations with a total of 60,000 h.p. On the lower reaches of the Isère many schemes are in hand which include the construction of stations at Pont d'Albertine (60,000 h.p.) Sainte-Hélène (25,000 h.p.), Romans (30,000 h.p.), Pizançon (40,000 h.p.) and at Beaumont-Monteux of 120,000 h.p., which will provide energy for the great works at Saint-Chamond. In the Southern Alps district, less developed than the northern area, the main schemes apply to the River Durance. At Argentière a station producing 40,000 h.p. is under construction, another at Ventavon of 43,000 h.p., and three stations under the control of the *Société d'Energie Electrique du Littoral Méditerranéen* will produce together 80,000 h.p., of which 50,000 will be supplied by the station at Sainte Tulle.

As regards the Rhône scheme, the threefold aim of which is to obtain electric power, to render the Rhône navigable up to the Swiss frontier, and to irrigate the land, the company has not yet been finally constituted. The increased cost of installation (in 1913 the average price was 100 to 200 francs per kilowatt, to-day it is 3,000 to 4,000 francs), as well as certain doubts as to whether power obtained therefrom by Paris, one of its chief customers, would be cheaper than that obtained from thermic-power stations near the capital, have contributed further complications in the realisation of the scheme, which with its eighteen works at a total cost of 3.6 milliards, is to provide 800,000 h.p. In the Jura, the Valserine, the Ain and the Doubs have all been exploited, and the work now in hand includes the erection of a powerful station on the Ain at Cize-Bolozen (24,000 h.p.) by the *Société l'Energie Electrique Rhone et Jura*, whilst the *Société des Forces motrices de la Loue* have almost completed a station at Mouthier (16,000 h.p.) on the Loue.

In the Pyrenees, development is also being accelerated especially in the case of the stations required to feed the railway lines. On the Aude, schemes are in hand for the creation of two new stations at Carcanet and Belvianes, which together will produce some 10,000 h.p. In the Perpignan area the Midi railway company is to create a powerful reservoir on the River Têt at Pla des Aveillands with a capacity of 12,000,000 cubic metres, which will regulate the supply of water to the three stations now existing at Pla des Aveillands, Fontpédrouse and Olette, whilst on the Ariège (a tributary of the Garonne) three stations capable of producing a total of 45,000 h.p. are to be erected at Saillens, Mérens and Aix-les-Thermes. On the River Neste d'Aure at Arreau, near Bagnères de Bigorre, a station producing 15,000 h.p. is in course of erection, and it is in this district (the district of the two rivers Neste de Louron and Neste d'Aure) that the most powerful stations of the Pyrenean district function. The River Garonne has also been exploited, but further development is under consideration, as meantime the power available has not been utilised to any appreciable extent.

In the Massif Central is the important river the Dordogne, for which large schemes are now in hand. The upper reaches of the river are to be exploited by the Paris-Orleans Railway Company from Haut-Chavanon to Vernéjoux, and the stretch from Vernéjoux to Brivezac has been conceded to the 17th Economic Region, which under a Government Bill of April, 1923, is to form a limited liability company of which the State and the municipalities are to be included in its shareholders. The Paris-Orleans scheme is well in hand; three stations are in course of erection (at Coindre, Cellette and Vernéjoux) and when completed will furnish power to the company for its railway services. The second scheme is at present in its infancy, but provides for the creation of four main stations (one at Chambon, two at Argentat, and one at Brivezac). The River Vienne, already utilised to the extent of 18,000 h.p., is the object of further schemes, which include the creation of stations at Saintes, Chardes (under construction at the present time) and at Jousseau (to be commenced at a later date). It is also intended to construct a reservoir on the Vienne with a capacity of eighteen million cubic metres. Schemes are also in hand as regards the Loire, the Lot and the Truyère; for the latter two stations capable of producing 10,000 h.p. are to be erected. On the Bès, a tributary of the Lot, a reservoir of 200,000,000 cubic metres is to be constructed by the *Société des Forces motrices de la Truyére* at Pradel, and later a second reservoir at Sarrans will be put in hand. At the second reservoir a station capable of producing 105,000 h.p., will be created at Brommat, and will be the most powerful within the region. In the southern district of the Massif central the Tarn is to be further exploited by the Paris-Lyons-Mediterranean Railway Company, and three stations are to be created at Pont-de-Montvert, Salles and Florac, with a total productive capacity exceeding 20,000 h.p.

(*To be concluded*).

GENERAL NOTES.

EARLY VOLUMES OF THE JOURNAL.—The Secretary of the Royal Society of Arts would be glad to hear from anyone who has for disposal a short run of the earlier Volumes of the *Journal*; Volumes 1, 2 and 3 are specially required.

Revival of Porcelain Manufacture in Vienna.—A new porcelain factory which was officially opened in Vienna recently is meant, says the United States Consul at Vienna, to revive the fame of the Imperial Royal Porcelain factory (K.K. Porzellanfabrik) which closed its doors in 1864 after 146 years of uninterrupted activities. The guiding idea of this undertaking is to maintain the high traditions of the former State porcelain factory and assure the public that its renown is to be resumed under a new aspect. This kind of production cannot turn out quantity goods, but aims at quality and artistic finish. The factory will produce cups, vases tea and dinner sets, and the old Viennese china mark, the beehive, will again be in evidence

MEETINGS OF THE SOCIETY TO APRIL 16, 1925.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock, unless otherwise announced:—

March 11. (4.30 p.m.)—Emile Cammaerts, "The Restoration of Belgian Towns." **Viscount Burnham, C.H., LL.D., will preside.**

March 18.—Claude N. Friese-Greene, "The Friese-Greene Process of Colour Cinematography." (Films will be shown to illustrate the process.)

March 25.—Henry G. Dowling, "Wall-papers."

April 1.—William Nunn, "Siam: its Prospects and Possibilities."

DOMINIONS AND COLONIES AND INDIAN SECTIONS. (JOINT MEETING.)

Thursday, April 16 (4.30 p.m.)—Lord Stevenson, G.C.M.G., "The British Empire Exhibition."

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

Monday, March 9..Swiney Lecture, King's College, Strand, W.C. 5.30 p.m. Dr. W. T. Gordon, "The Geological History of Plants." (Lecture V.)

Transport, Institute of, (Midland Section). Chamber of Commerce, Birmingham. 6 p.m. Mr. F. Rayner, "Development of the Trent Navigation."

Brewing, Institute of, (London Section), at the Engineers' Club, Coventry Street, W. 7.30 p.m. (1) Messrs. A. C. Chapman and C. W. McHugo, "The Reaction of the Mashing Liquor in relation to Extract Yield and Soluble Non-coagulable Nitrogen." (2) Messrs. H. F. E. Hulton and J. L. Baker, "Note on the Residual 'Assimilable' Nitrogen in Beer in relation to Stability."

Surveyors' Institution, 12, Great George Street, S.W. 8 p.m.

Metals, Institute of, (Scottish Section), 39, Elmbank Crescent, Glasgow. 7.30 p.m. Mr. A. G. Lobley, "Electric Furnaces."

Geographical Society, 135, New Bond Street, W. 8.30 p.m. Mr. A. F. R. Wollaston, "The Sierra Nevada of Santa Marta, Columbia."

Electrical Engineers, Institution of, (N. Eastern Centre), at the Armstrong College, Newcastle-on-Tyne. 7.15 p.m. Major E. I. David, "Electricity in Mines."

Embroiderers' Guild, Lecture Theatre, Victoria and Albert Museum, South Kensington, S.W. 3 p.m. Mrs. Rolleston, "Character in Embroidery.'

City of London College, White Street, Moorfields, E.C. 5.30 p.m. Signor G. Boggi, "Commercial Development in Italy."

University of London, University College, W.C. 5.30 p.m. Miss E. J. Davis, "Some Famous London Bridges."

5.30 p.m. Prof. H. Westergaard, "Vital Statistics." (Lecture I.)

At King's College, Strand, W.C. 5.30 p.m. Dr. R. W. Seton-Watson, "The Origins of the War in its Balkan Aspect." (Lecture IV.)

5.30 p.m. Rev. C. F. Rogers, "Ecclesiastical Music." (Lecture VII.)

At Bedford College, Regent's Park, N.W. 5.15 p.m. Prof. L. Levy-Bruhl, "Trois Philosophes Français Contemporains: Ribot, Espinas, Durkheim." (In French.) (Lecture I.) Lecture II and III on the 10th and 13th March.

Automobile Engineers, Institution of, at the Chamber of Commerce, Birmingham. 7 p.m. Mr. D. Finlayson, "Carburation."

Victoria Institute, Central Buildings, Westminster, S.W. 4.30 p.m. Rev. C. Gardner, "Nature and Supernature."

Tuesday, March 10..Petroleum Technologists, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 5.30 p.m. Annual General Meeting. Address by Mr. H. Barringer.

Automobile Engineers, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 7 p.m. Mr. D. Finlayson, "Carburation."

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Prof. S. M. Dixon and Mr. F. W. Macaulay, "Measurements of Discharge over a Rock-faced Dam."

Electrical Engineers, Institution of, (N. Midland Centre), at the Technical College, Bradford. 7 p.m. Mr. H. W. Taylor, "Three-Wire Direct-Current Distribution Networks. Some Comparisons in Cost and Operation."

(Scottish Centre), at the North British Station Hotel, Edinburgh. 7 p.m. Mr. E. Hughes, "Iron Losses in Direct Current Machines."

Anthropological Institute, 50, Great Russell Street, W.C. 8.15 p.m.

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C. 8.30 p.m. Hon. Sir Arthur Myers, "New Zealand: its Development and Position in the Empire."

Transport, Institute of, (Graduates' Section), at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C. 5.30 p.m. (1) Mr. C. F. King, "Industrial Traffic Management." (2) Mr. H. G. Scott, "Some Notes on the Carriers Act."

Asiatic Society, 74, Grosvenor Street, W. 4.30 p.m. Dr. A. M. Blackburn, "The Treasure Tombs of Luxor."

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. E. N. da C. Andrade, "The Evolution of the Scientific Instrument."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Annual General Meeting.

University of London, University College, Gower Street, W.C. 5.30 p.m. Mr. R. A. Smith, "The Old Stone Age."

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia from 1861." (Lecture VIII.)

At the Imperial College of Science, South Kensington, S.W. 5.30 p.m. Prof. C. A. Edwards, "Chemical Combination in Metallic Alloys and its Nature." (Lecture III.) Lecture IV. on 11th March.

WEDNESDAY, MARCH 11..Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

Swiney Lecture, King's College, Strand, W.C. 5.30 p.m. Dr. W. T. Gordon, "The Geological History of Plants." (Lecture VI.)

United Service Institution, Whitehall, S.W. 3 p.m. Mr. W. E. Arnold-Forster, "Maritime Law and Economic Pressure."

Oriental Studies, School of, London Institution, Finsbury Circus, E.C. 5.15 p.m. Mr. E. Richmond, "Early Moslem Architecture" (Lecture V.)

Electrical Engineers, Institution of, (S. Midland Section), at the University, Birmingham. 7 p.m. Major E. I. David, "Electricity in Mines."

Civil Engineers, Institution of, Great George Street, S.W. 7 p.m. (Informal Meeting). Mr. J. S. Wilson, "The Relative Importance and Nature of Secondary Stresses in Steel Structures."

Metals, Institute of, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W. 10 a.m. Annual General Meeting. (1) Messrs. H. T. Angus and P. F. Summers, "The Effect of Grain-Size upon Hardness and Annealing Temperature." (2) Mr. S. L. Archbutt, "A Method of Improving the Properties of Aluminium Alloy Castings. (3) Mr. U. R. Evans, "Surface Abrasion as a Potential Cause of Localised Corrosion." (4) Dr. F. J. Newton, and Mr. J. S. Tidmus, "The Influence of Emulsoids upon the Rate of Dissolution of Zinc in Solutions of Lead, Nickel and Copper Salts."

2 p.m. (5) Mr. T. G. Bamford, "Comparative Tests on Some Varieties of Commercial Copper Rod." (6) Messrs. R. Genders and G. L. Bailey, "The Alpha Phase Boundary in the Copper-Zinc System." (7) Dr. D. Bunting, "The Influence of Lead and Tin on the Brittle Ranges of Brass." (8) Mr. E. A. Bolton, "The Removal of Red Stains from Brass.'"

University of London, University College, Gower Street, W.C. 5.30 p.m. Miss E. S. Fegan, "Library Resources Outside London."

5.30 p.m. Mr. I. Björkhagen, "The Swedish Novel from Almquist to Strindberg." (Lecture II.)

5.30 p.m. Prof. H. Westergaard, "Vital Statistics." (Lecture II.)

At King's College, Strand, W.C. 5.30 p.m. Prof. E. Prestage, "The Opening of the Ocean Routes, A.D. 1415-60."

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Prof. P. Lehman, "Anglo-German Script in the Germany of the Middle Ages." (Lecture I.)

Chemical Engineers, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, Westminster. S.W. 8 p.m. Prof. A. L. Mellanby, "Expansion and Compression Phenomena in Steam Jets."

THURSDAY, MARCH 12..Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p.m.

Royal Institution, Albemarle Street, W. 5.15 p.m. Dr. Leonard Hill, "The Biological Action of Light." (Lecture I.)

Historical Society, 22, Russell Square, W.C. 5 p.m. Miss A. Moller, "Coal Mining in the Seventeenth Century."

Metals, Institute of, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W. 10 a.m. Annual Meeting continued. (1) Messrs. G. L. Bailey and R. Genders, "The Density and Constitution of the Industrial Brasses." (2) Mr. A. L. Norbury, "Note on the Effects of Certain Elements on the Electrical Resistivity of Copper." (3) Sir T. K. Rose, "On the Density of Rhodium." (4) Professors Kôtaro Honda and Ryonosuke Yamada, "Some Experiments on the Abrasion of Metals." (5) Prof. Tomimatu Isihara, "On the Equilibrium Diagram of the Aluminium-Zinc System."

Textile Institute, 38, Bloomsbury Square, W.C. 5.45 p.m. Mr. T. Kirby, "Shrinkage, Stretch, and Elasticity of Knitted Goods."

Electrical Engineers, Institution of, (Irish Centre). Trinity College, Dublin. 7.45 p.m. Dr. J. F. Crowley, "The Use of Electricity in the Chemical Industries, with particular reference to the Irish Free State."

(Local Sub-Centre), at the University College, Dundee. 7.30 p.m. Mr. J. S. Thomson, "Some Problems of County Distribution."

Victoria and Albert Museum, South Kensington, S.W. 6 p.m. Mr. O. Brackett, "Chippendale Furniture."

London County Council, at the Geffrye Museum, Kingsland Road, E. 7.30 p.m. Mr. S. B. Wainwright, "The Use of Plywood in Furniture and Decoration."

Mechanical Engineers, Institution of, (Western Section), at the Merchant Venturers' Technical College, Bristol. 7 p.m. Mr. J. B. Dahlerns, "Anti-Friction Bearing Applications for Heavy Duty."

(Graduates' Section, N. Western Branch), at the Engineers' Club, Albert Square, Manchester. 7.15 p.m. Mr. G. Lyon, "High-Speed Petrol Engines."

Electrical Power Engineers' Association, at the Geographical Hall, Deansgate, Manchester. 7.15 p.m. Mr. J. N. Waite, "Combustion and Boiler House Efficiency."

University of London, University College, Gower Street, W.C. 5 p.m. Mr. G. A. Sutherland, "Auditorium Acoustics." (Lecture III.)

At King's College, Strand W.C. 5.30 p.m. Dr. A. R. Pastor, "Spanish Saints and Heretics." (Lecture III.)

6.30 p.m. Dr. O. Vocadlo, "Czech Civilisation." (Lecture IX.)

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Prince D. S. Mirsky, "Russian Literature in the Second Half of the Nineteenth Century." (Lecture VIII.)

FRIDAY, MARCH 13..London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 5 p.m. Mr. R. Blunt, "A Chelsea Pilgrimage."

Royal Institution, Albemarle Street, W. 9 p.m. Prof. G. Murray, "The Beginnings of the Science of Language."

Astronomical Society, Burlington House, Piccadilly, W. 5 p.m.

Engineers, Junior Institution of, 39, Victoria Street, S.W. 7.30 p.m.

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 6 p.m. (1) Prof. E. G. Coker, "The Action of Cutting Tools." (2) Messrs. D. Smith and A. Leigh, "Experiments with Lathe Tools on Fine Cuts, and some Physical Properties of the Tool Steels and Metal opera'ed on."

(Graduates' Section, Midland Branch), at the Chamber of Commerce, Birmingham. 7.30 p.m. Joint Discussion with Local Students of Inst.C.E. and I.E.E. on "Modern Transport Problems."

Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W. 6 p.m.

University of London, King's College, Strand, W.C. 5.30 p.m. Baron A. F. Meyendorff, "The Russian Church, Past and Present." (Lecture II.)

Shakespeare Association, King's College, Strand, W.C. 5.30 p.m. Prof. H. B. Charlton, "The Idea of Romantic Comedy in Shakespeare."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. F. Judge, "Many Slides and a few Remarks."

Physical Society, Imperial College of Science, South Kensington, S.W. 5 p.m. (1) Mr. J. P. Andrews, "The Variation of Young's Modulus at High Temperatures." (2) Mr. E. G. Richardson, "The Critical Velocity of Flow Past Objects of Aerofoil Section." (3) Mr. J. Brebtano, "A Focussing Method of Crystal Powder Analysis by X-rays."

SATURDAY, MARCH 14..Royal Institution, Albemarle Street, W. 3 p.m. Sir Ernest Rutherford, "The Counting of the Atoms." (Lecture IV.)

London County Council, at the Horniman Museum, Forest Hill, S.E. 3.30 p.m. Dr. R. L. Sherlock, "Man as a Geological Agent."

JOURNAL OF THE ROYAL SOCIETY OF ARTS

No. 3773 VOL. LXXIII.

FRIDAY, MARCH 13, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

WEDNESDAY, MARCH 18th, at 8 p.m. (Ordinary Meeting.) CLAUDE H. FRIESE-GREENE, "The Friese-Greene Process of Colour Cinematography." J. DUDLEY JOHNSTONE, President, Royal Photographic Society, will preside. (The paper will be illustrated by films in natural colours.)

THIRTEENTH ORDINARY MEETING.

WEDNESDAY, 4th MARCH, 1925. SIR HERBERT JACKSON, K.B.E., F.R.S., in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Crerar, Lieut.-Colonel Robert, O.B.E., Enfield, Middlesex.
Crossland, Ernest Milling, Manchester.
Deanesly, Henry, Terenure, Co. Dublin.
Harding, A. Leigh, Wallington, Surrey.
Landrum, W. W., D.D., Russellville, Kentucky, U.S.A.
Mew, Henry Bertram, Huntingdon.
Nielson, Harald, London.
Rogers, Robert, Southampton.
Whitaker, Major George Cecil, London.
Whitaker, Mrs. Margaret, London.
Woodbury, Edward Berkeley Carlton, London.

The following candidates were duly elected as Fellows of the Society :—

Burns, Alan Chamley, M.Sc., F.I.C., Whitehaven, Cumberland
Cohen, George, London.
Cooksley, Allan, Birmingham.
Dow, Alexander, London.
Dunhill, Alfred, Harrow Weald, Middlesex.
Henry, William Ethelbert, Maidenhead, Berks.

Hirniak, Dr. Julian, Lwow, Poland.
Howatson, Lieut. G. A. S., I.M.D., Almora, India.
Jessop, Arthur, Rawdon, Leeds.
Marsden, Andrew, M.I.Mar.E., Gravesend, Kent.
Rowe, Harold Charles, J.P., Exeter.
Sadhu, Pandit Tara Chand, Srinagar, Kashmir, India.
Simmonds, Ernest John, Gerrard's Cross, Bucks.
Yates, Charles, Hailey Hall, near Hertford.

A paper on "The Modern Production of Sheet-glass," was read by Professor W. E. S. Turner, O.B.E., D.Sc., F.Inst.P., Department of Glass Technology, University of Sheffield.

The paper and discussion will be published in a subsequent number of the *Journal.*

INDIAN SECTION.

FRIDAY, 6TH MARCH, 1925. THE RT. HON. VISCOUNT CHELMSFORD, G.C.S.I., G.C.M.G., G.C.I.E., G.B.E., in the Chair.

A paper on "The Development of Indian Universities" was read by SIR HENRY SHARP, C.S.I., C.I.E., M.A.

The following took part in the discussion :—Sir Claude F. de la Fosse, C.I.E., M.A., late Director of Public Instruction, United Provinces; Principal Mohan Lal Tannan, Sydenham College, Bombay; Dr. F. W. Thomas, M.A., Ph.D., Librarian, India Office; Mr. Thomas W. Hodgkinson; Colonel Sir Charles E. Yate, Bt., C.S.I., C.M.G., and Sir Robert W. Carlyle, K.C.S.I., C.I.E.

The paper and discussion will be published in a subsequent number of the *Journal.*

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1925 early in May next, and they therefore invite Fellows of the Society to forward to the Secretary on or before Saturday, March 21st, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce."

The list of those who have received the medal since its institution in 1864 was printed in the last number of the *Journal.*

TEN-VOLUME INDEX TO "JOURNAL."

The amalgamated Index to the *Journal of the Royal Society of Arts* for Vols. LXI.-LXX. (1912-1922) is now ready, and can be obtained free by Fellows of the Society on application to the Secretary, Royal Society of Arts, John Street, Adelphi, London, W.C. The price to non-Fellows is 2*s.* 6*d.*

PROCEEDINGS OF THE SOCIETY.

NINTH ORDINARY MEETING.

EIGHTH TRUEMAN WOOD LECTURE.

WEDNESDAY, FEBRUARY 4TH, 1925.

MR. ALAN A. CAMPBELL SWINTON, F.R.S. (Late Chairman of the Council), in the Chair.

THE CHAIRMAN expressed regret that Senatore Marconi was unable to take the Chair that evening owing to illness. He had sent his expressions of regret that he was not able to be present upon such an important occasion as the delivery of the Trueman Wood Lecture. These lectures had been instituted seven years ago to commemorate the services of Sir Henry Trueman Wood, who had been connected with the Royal Society of Arts for some 41 years, first of all for 3 years as Assistant Secretary, and then for no less than 38 years as Secretary. Unfortunately Sir Henry was not able to be present that evening, but he thought Sir Henry would appreciate it if, on behalf of the meeting, he asked the Secretary to send to him a message of goodwill.

The first Trueman Wood Lecture was given in 1917, when the lecturer had been Sir Dugald Clerk and the subject "Discovery and Invention." Next in 1919 the Lecture had been given by Sir Herbert Jackson on "Glass, and Some of its Problems." In 1920 the Lecture had been "Sources of Power, Known and Unknown," by Sir Oliver Lodge. In 1921 it had been on "The Present Position of Research in Agriculture," by Sir Daniel Hall, and in 1921, again, on "Long Distance Radio-Telegraphy," by Professor J. A. Fleming. In 1923 the Lecture had been on "New Methods of Crystal Analysis," by Sir William Bragg, and in 1924 on "The Outlook in Chemistry," by Sir William Pope. As would be seen, there had been lectures on a variety of subjects, all by masters in their particular spheres. He thought that in the future there might be difficulty in keeping up to such a very high standard, but at all events there was no difficulty of that sort on the present occasion, for in the Cavendish Professor of Physics of Cambridge University they had a past master of his subject.

Before he sat down he would like to remind the audience that Sir Ernest Rutherford had recently received from His Majesty the very high honour of the Order of Merit. He was sure they all wished to congratulate Sir Ernest very warmly on that distinction.

The lecture delivered was :—

THE STABILITY OF ATOMS.

By PROFESSOR SIR E. RUTHERFORD, O.M., F.R.S.

The trend of Physics during the past twenty-five years has been largely influenced by three fundamental discoveries that were made in the closing years of the nineteenth century. I refer to the discovery of the X-rays in 1895, of radioactivity in 1896 and the proof of the independent existence of the negative electron of small mass in 1897. The development of each of these discoveries in its own particular field has proceeded rapidly and given us a wealth of new and valuable information which has proved in many cases to be of technical as well as of philosophical importance. While each of these lines of enquiry has in a sense developed independently and provided its own technical methods, a closer examination shows that these three lines of progress are all closely related and have mutually interacted at all stages of the advance. This is most clearly shown by the influence each of these discoveries has exerted on the fundamental problem of the constitution and relation of the atoms of the elements. Without the information derived from any one of these new lines of study, the development of our ideas of atomic structure would have been much more slow and hesitating, and it is doubtful whether we could have hoped to obtain any clear idea of the essential features of the structure of the atom.

The discovery of the electron and the proof that it is a constituent of the structure of all the atoms, gave us the first definite line of attack on the constitution of the atom, while the interpretation of the Zeeman effect showed that the optical spectra of the elements were due in some way to the vibration of these mobile electrons.

The development of methods for obtaining intense sources of electrons at controllable speeds opened up a new and powerful method of attack on the structure of the atom and the origin of the light and X-ray spectra.

The study of the X-rays and particularly the proof of the wave nature of X-rays and their diffraction by crystals gave us for the first time a method for studying quantitatively the modes of vibration of the electrons situated deep within the structure of the atom, while the presence of absorption bands in the X-ray spectra gives us information of the greatest value on the arrangement of the electrons in definite groups or levels.

It is to the study of radioactivity, however, that we owe our most definite information on the main structure of the atoms. It gave us for the first time a definite proof that the atoms of the heavier elements like uranium and thorium were not permanently stable but broke up occasionally with explosive violence with the emission of characteristic radiations of new and powerful types. It brought to light that wonderful series of successive transformations with the appearance of more than thirty new elements which are differentiated not only by their chemical properties but by the character of their transformations. The study of the radiations gave us the first clear idea of the enormous intensity of the forces that must reside within the disintegrating atoms and of the magnitude of the energy liberated in these atomic explosions.

The examination of the chemical properties of these radioactive elements, often existing in minute amounts, first disclosed the existence of isotopes of elements of almost identical physical and chemical properties but differing in mass and in radioactive qualities. This has been followed by the development of methods to show that many of the common radioactive elements also consist of a mixture of two or more isotopes.

The radioactive processes brought to our attention a new type of chemical change, which was spontaneous and uncontrollable by any known physical or chemical agency and accompanied by an emission of energy per atom in the form of characteristic radiations enormous compared with that involved in ordinary chemical reactions. The emission of the energetic α particle, the swift β ray and the penetrating γ ray provided us with new types of radiation for study, of an individual intensity that has so far not been equalled by laboratory methods. The α particle has so much energy that it is able to pass freely through the structure of the atom in its path. By studying the large deflection often suffered by an individual α particle in its passage through an atom, definite evidence was obtained of the nuclear structure of the atom and of the magnitude of the nuclear charge and thus of the number of the electrons in the outer atom.

For the purposes of discussion, it is convenient to consider that the structure of the atom consists of two parts, one the minute charged nucleus which contains most of the mass of the atom, and whose charge controls the number and arrangement of the outer electrons, and the other the outer or planetary electrons which extend far from the nucleus and give the atom the dimensions usually attributed to it. The motion of these electrons is responsible not only for the characteristic light spectra of the atom but also for its high frequency X-ray spectra, while the position and motion of the more outlying electrons govern the ordinary physical and chemical properties attributed to the atom.

On the classical theory, it was impossible to devise a stable system of electrons in motion round a nucleus, since a moving electron radiated energy and would ultimately fall into the nucleus. In order to overcome this fundamental difficulty it was necessary to invoke the aid of the quantum theory of radiation, first put forward by Planck in 1900, although its full significance and importance was not recognised until a decade later. This remarkable theory, initially developed to explain the distribution of energy in the spectrum of a hot body, supposes that radiation is emitted in definite quanta depending in magnitude on the frequency of the radiation. The energy E in a light quantum is given by $E = h\nu$ where ν is the frequency of vibration of the radiation and h a universal constant known as " Planck's constant." It is not my intention here to discuss the underlying difficulties involved in this view of radiation, but it suffices to say that its essential correctness has been shown by experiments in widely different fields. Bohr applied the ideas of the quantum theory not only to fix the distribution of the outer electrons round a nucleus, but also to account for both the light and X-ray spectra of the atom.

The further development of these ideas has not only given us a clear picture of the arrangement and motions of the electrons round the nucleus but also a definite idea of the interchanges of energy involved in the emission and absorption of radiation in the atom. In the course of this work, the ideas of the quantum theory have received a wide extension largely due to the work of Bohr Sommerfeld and others.

It is not my object in this lecture to enter into the difficult questions of the actual arrangement and motions of the outer electrons in different atoms, but rather to give a brief account of the changes that are believed to occur in the outer atom during the absorption or emission of energy, and thus to illustrate the stability of the outer atom under different forms of excitation. At a later stage of the lecture, we shall consider how far these ideas, derived from a study of the outer atom, can be applied to explain the structure and modes of vibration of the atomic nucleus.

To illustrate the processes involved in the excitation of the atom and the emission of radiation, let us first consider the simplest possible case, viz., the origin of the line spectra emitted by hydrogen due to an electric discharge in that gas at low pressure. We know that the hydrogen atom in its ordinary or normal state consists of a nucleus of one positive charge with one attendant electron, which is believed to describe a circular orbit round the nucleus. Notwithstanding the extreme simplicity of this structure ascribed to the hydrogen atom, we know that the hydrogen atoms under excitation give a complicated bright line spectrum. It is well known that this spectrum, extending from the extreme ultra-violet to the infra-red, can be analysed into three simple series known by the names of Lyman, Balmer and Paschen. We omit here altogether the complicated secondary spectrum emitted by hydrogen under some conditions of excitation, which is ascribed to the vibrations of the hydrogen molecules and not to the vibrations of the individual free atoms.

In order to explain the complex modes of vibration of the single electron attached to the hydrogen nucleus, Bohr supposed that under appropriate conditions of excitation, the electron could be displaced from its normal orbit and occupy one of a series of stationary states, or levels of higher energy relative to the nucleus, which are defined by simple quantum conditions. The energy of the level relative to the nucleus is most conveniently expressed in terms of volts. For example, the energy required to move the electron from the normal state or first level to a great distance is equal to the energy acquired by an electron in falling freely between two points differing in potential by 13.54 volts. The corresponding energies in the following levels are connected by simple numerical relations viz., 1/4, 1/9, 1/16, etc., of the energy of the first normal level, i.e., 3.38, 1.50, .84 volts respectively. The series of levels for the hydrogen atom is shown diagrammatically in Fig. 1 where the logarithms of the energy in volts is taken as ordinate. It is seen that the difference of energy between levels defined by the quantum numbers 1 and 2 is 13.4-3.38 or 10.16 volts.

Now it is supposed that the electron can only remain a short time in one of these stationary levels, but falls from a higher to a lower level, emitting during the process radiation of definite frequency ν defined by $E = h\nu$ where E is the difference of potential energy of the electron in the two levels. No definite physical explanation can be given why an electron emits homogeneous radiation during such a jump from one level to another. The origin of the lines in

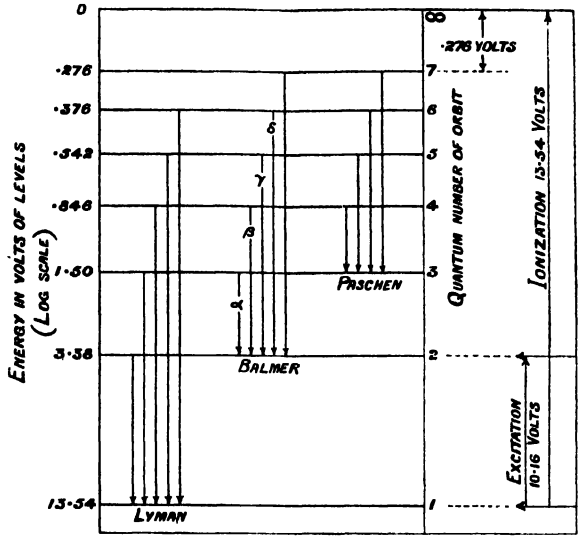


FIG. I.

the different series is clearly shown in the diagram. The ordinary simple spectrum of hydrogen comprising the well known α, β, γ and δ lines arises from the jump of the electron from higher levels 3, 4, 5, 6 to the level 2, the Lyman series in the ultra-violet arises from jumps of the electrons from the successive higher levels to the level 1. The frequency of each of the spectral lines in the different series can be deduced at once from the energy of the different levels using the quantum relation. By adopting such a series of levels, the whole line spectrum of hydrogen can be simply accounted for. We should expect another series in the ultra-red due to the fall of an electron from higher levels to the level 4 and some of the lines of the new series have recently been found by Brackett.

We are now in a position to form a mental picture of some of the processes at work in the excitation of the hydrogen spectra by the electric discharge. Under the influence of bombardment of the electrons in the discharge, some of the molecules are dissociated into free neutral atoms and occasionally by collision or other agencies the atom is " excited " i.e., an electron is moved from its normal level in the atom into a level of higher energy. After a short interval this electron falls back again into a level of lower energy emitting radiation of characteristic frequency in the process. In the discharge at any moment when a large number of atoms are involved, hydrogen atoms will exist in all possible states of excitation and radiation of corresponding frequencies will be emitted. When a steady state is reached, obviously on the average the number of electrons that are lifted by the agency of the discharge from one definite level to another per second, will be equal to the number which fall between these levels, although different atoms may be involved in the two cases.

We have not so far referred to another process which must be going on in the electric discharge. Some of the hydrogen atoms will be given by electronic impact sufficient energy to remove entirely the electrons from the atoms, i.e., to ionize them, leaving the resultant nucleus with one positive charge. Electrons of all speeds are present in the discharge, and under appropriate conditions in the course of time one of them may fall towards the nucleus and occupy momentarily one of the possible energy levels. This will then fall by one or more stages into the normal orbit of the hydrogen atom, emitting the corresponding radiations in the process.

So far we have been dealing only with the process of emission of radiation from an atom, but the same general ideas can be applied to explain the absorption of radiation and the appearance of absorption lines in spectra under special conditions. Suppose for example, radiation of a frequency exactly corresponding to the difference of levels 1 and 2, i.e., of 10.16 volts, falls on hydrogen atoms. It will be absorbed by the atom and will lift the electron from the level 1 to the level 2 and the electron in falling back will emit excited radiation in all directions of frequency equal to the incident radiation. Absorption of radiation will not be produced by a radiation of frequency H_α corresponding to a transition from level 3 to 2, as no levels of this kind exist in hydrogen in the normal state. If, however, light of frequency H_α is passed through hydrogen in which the atoms are in all possible excited states due to the passage of an electric discharge, an absorption, i.e., a reversal of the line has been observed.

On these views, we see that an atom may be excited to emit radiation either by impact or by the action of radiation of appropriate frequency. The energy required for this purpose may not only be given by collisions with electrons but also by collisions with positively or negatively electrified atoms of sufficient energy.

The changes which occur in the hydrogen atom whether by radiation or electronic impact have so far been expressed in terms of the characteristic energy levels of the electron relative to the nucleus. As the excitation and absorption of radiation is always accompanied by definite changes of energy of the atomic system, corresponding to the transitions of the electron between the energy levels involved, this mode of view suffices to give a clear if elementary picture of the processes involved. If, however, we look deeper into the question, these levels are interpreted on the quantum theory in terms of the motions of the electron. The latter is supposed to describe an orbit round the nucleus without radiation of energy. The character of the orbit is defined by certain quantum numbers. When the change of mass of the electron with speed, i.e., the relativity correction, is taken into account, some of these nearly orbits are not closed but rotate round the nucleus. Sommerfeld has shown that this precession of the orbit accounts quantitatively for the fine structure shown by many of the hydrogen lines. In the present lecture, when the discussion is mainly confined to energy changes possible in an atomic system, we shall in general use the conception of levels although it is often convenient to speak of the transfer of an electron from one orbit to another. It is of interest to note that the interpretation of spectra, which has seen so rapid an advance in the last few years under the impulse of these new ideas, can be based entirely on energy levels without necessarily any assumption as to the character of the orbit described by the electron. In the short time at our disposal, we cannot enter into the question of the complicated changes produced in the emission spectra when the atoms are exposed to strong magnetic or electric fields. These phenomena, known respectively as the Zeeman and Stark effects, are capable of complete explanation by the quantum theory and indeed this theory predicted a number of new phenomena which have been verified subsequently by experiment.

We have so far confined our attention to the processes involved in the production of the spectra due to hydrogen atoms, for it has been found that the same general ideas may be applied to explain the often very complicated spectra given by elements which contain a number of electrons. Such a result is to be expected from Bohr's theory of spectra and has been confirmed experimentally in a variety of ways.

Suppose, for example, we consider the types of spectra which can be emitted by an element like aluminium or silicon which has a number of planetary electrons. Suppose that the vapour of these elements is exposed to bombardment by an intense stream of electrons of known energy. When the energy of the bombarding electrons is raised to a certain value, one of the outermost or " valence" electrons of the atom may be excited, i.e., lifted to the next higher energy level, and describe a new orbit. This in falling back to its original orbit emits radiation of definite frequency thus giving rise in some cases to a " single line " spectrum. If the speed of the bombarding electrons is increased, the electron may be lifted to all possible levels, and the resulting radiation due to the various possible transitions gives rise to the full spectrum. This spectrum may be analysed into series very similar in general form to those observed for the hydrogen atom. This spectrum, due to the neutral atom, is generally known as the first or arc spectrum. If, however, the vapour or gas is exposed to a very intense bombardment by high speed electrons, some of the atoms may lose one or more of their outer electrons. When the singly ionized atoms are bombarded, another of the electrons may be displaced to occupy one of the possible higher levels and a new spectrum will result of the same general series type, generally known as the second or spark spectrum. Similarly third and fourth spectra may arise from doubly and trebly ionized atoms. During the last few years, these higher spectra have been obtained and analysed for a few elements. For example, Fowler has observed the spectrum due to neutral, singly doubly and trebly ionized silicon, Paschen for singly and doubly ionized aluminium, while Millikan has found some lines which must be ascribed to the sixth spectrum of oxygen and sulphur, i.e., to quintuply ionized atoms of these elements. Since oxygen has 8 outer electrons, the removal of 5 leaves an electron arrangement round the oxygen nucleus similar to that of the lithium atom which contains 3 outer electrons, and should give a similar type of spectrum. By using very intense electronic bombardment, it may ultimately be possible to analyse in detail the successive spectra observed for many elements corresponding to successive stages of its ionization. Since in a strongly ionized gas, all these types of spectra may appear together, we can understand the great apparent complexity of some of these spectra.

Not only are these various types of spectra analogous in type and expressed by series relations like the spectra of hydrogen but a simple numerical relation exists between the Rydberg constant for the successive spectra. For example the Rydberg constant for the first, second, third and fourth, etc., spectra of an element are in the ratio $1^2, 2^2, 3^2, 4^2$, etc. Such a simple relation is predicted in Bohr's general theory of spectra from the resultant charge of the atom.

We must pass on for a moment to consider the origin of the X-ray spectra of the elements which arise from the vibration of the more lightly bound inner electrons of the atom. We know from the work of Bohr, that the electrons may be arranged in a number of groups or levels around the nucleus. The first " K " level contains two electrons, the second " L " level consists of 8 electrons, the M level 18 electrons when completed but divided into a number of sub-groups and so on. The existence of these levels has been clearly shown by the evidence of X-ray spectra in general, and very directly by the absorption edges which are clearly shown when a complex beam of X-rays is analysed after passing through a layer of the element under consideration. A rough diagram of the main levels of a heavy atom is shown in Fig. 2. In order to excite the highest frequency spectrum, the " K " spectrum, one of the K electrons from the inner group must be given sufficient energy either by impact or absorption of radiation energy, to lift it either right out of the atom or at any rate to one of the outer optical levels. The K-group tends to reform by the fall of an electron

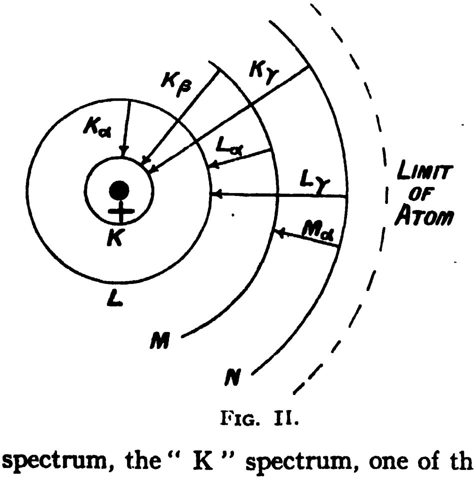


Fig. II.

from one of the outer L or M levels. The fall of the electron from the L level gives the K_α line, from an M level the K_β line, and so on. The fall of the electron from the L level leaves a vacant place to be filled up, and this may be done by the fall of an electron from an M or N level, etc., and so the process continues uutil the atom is reorganised and all the levels are filled as before. We thus see that the reconstruction of an atom after the removal of a K-electron not only gives rise to K lines but to lines of lower frequency due to transitions between the outer levels. The actual spectra are somewhat more complicated than on the above simple explanation, but it is only my object here to give the broad principles involved without detail.

It is of interest to note that the spectrum due to the inner groups of electrons can only be obtained by actually moving an electron outside the atom, or at at any rate to one of the outer or optical levels of the atom. There is as yet no evidence that we can obtain spectra due to the mere displacement of an electron in a completed group to another neighbouring orbit of higher energy corresponding to the single line spectrum of a neutral atom.

From the foregoing discussion, it is seen that the electronic system of the atom can absorb and momentarily store energy in the form of greater potential energy relative to the nucleus of one or more of the constituent electrons. The amount of this energy per atom involved is considerable even in the case of excitation of optical levels, amounting to a few volts. It becomes greater for the removal of the more deep seated electrons and in the case of a heavy element where a K-electron is displaced from the K-ring to an optical level may amount to about 100,000 volts. As we have seen, this additional potential energy may be given to the electronic system either by the passage through the atom of swift electrons and charged atoms, or by the absorption of radiation of appropriate frequency.

The very interesting question arises as to the length of time this energy can be stored in an atom before being liberated afresh in the form of radiation by the return of the disturbed electron to its normal position in the atom. In the general case, it is difficult to obtain experimental evidence on this point but in a few cases the average life of an electron in an outer orbit has been measured. This has been done by Wien for the hydrogen lines H_β and H_γ by observing the decrease of luminosity of swift hydrogen atoms generated in a discharge tube during their flight through an exhausted space. In this way he found the average life of an electron in level 4 or level 5 to be about one fifty millionth of a second. A time of the same order of magnitude has been found for the mercury atom in the excited state. Milne has estimated from astrophysical data an even shorter life for an ionized calcium atom. The evidence, as far as it goes, thus indicates that the life of an excited atom is very short so that energy can only be stored in the atom for a very limited time. We have no evidence of the time required to reorganise an atom when, for example, a K-electron is ejected from the atom of a heavy element, but it is to be anticipated that it would be a very minute fraction of a second. It may be, as Tolman has suggested, that, in some cases of excitation the duration may be of the order of a second, for example in the case of an excited molecule. However, this is a case where the rate of vibration is not only much slower but the mass of the vibrators are great compared with that of the electron.

It has been suggested that the life of an electron in a temporary orbit, like the life of a radioactive element, is governed purely by the laws of chance and not influenced by external disturbances. This is an interesting possibility but so far the evidence on this point is somewhat indefinite.

There is another way, however, in which an atom may possibly act as a storer of energy for long periods. This is best illustrated by the case of the helium atom. In its normal state the helium atom contains two electrons circulating in similar nearly circular orbits round the nucleus. The energy required to remove one electron, i.e., to ionize the atom, is 24.5 volts. Under certain conditions, however, helium may exist in the metastable state in which the outer electron describes an orbit with an ionization potential of only about 6 volts. The energy per atom liberated by the change of the atom from the metastable to the normal state is very large, amounting to about 19 volts. There is reason to believe that a helium atom in the metastable state would be permanently stable if isolated in space. Apparently however, by collision with other atoms, or with the walls of the containing vessels, there is a rapid reversion to the ordinary stable state. For this reason it seems unlikely that energy can be stored in such atoms under practical conditions for more than a short time. There is always the possibility that such metastable states of higher potential energy than the normal may exist for the deep seated levels of the atom, but so far there is no experimental evidence of this.

It is seen that although the electronic system may be subject to violent disturbances and may even lose a number of its electrons, the alteration is very temporary and the atom under normal conditions rapidly returns to its original state. Even if it were possible to strip away all the outer electrons and leave a bare nucleus, in the presence of free electrons the atom would be rapidly reconstructed with the emission of radiation. It seems clear that in some respects the electronic system of an atom is extraordinarily stable, for even if one or more of the constituents is removed by suitable agencies, the residual system does not break up or reorganise itself into an entirely new system. Whatever the disturbance, the atom always returns to its final state, and under normal conditions this requires a very short interval of time.

Mention should be made at this stage of a striking property of atoms in an excited state. It has been found that in certain types of collision between two atoms known as " collisions of the second class " it is possible to transfer part of the potential energy of an atom in an excited state so as to excite another atom without the emission of radiation. The idea of such transfers of energy between two systems was first suggested on theoretical grounds by Klein and Rosseland

and the proof of its correctness has been supplied by the striking experiments of Franck and Cario. A simple case may be taken in illustration. Suppose we have a mixture of mercury and thallium atoms and that the mercury atoms are excited by the absorption of radiation corresponding to 4.9 volts. Some of the collisions of the excited mercury atoms with those of thallium cause the excitation of the thallium atoms and the consequent emission of some lines of the thallium spectrum. In the absence of mercury no effect is produced by the exciting radiation on the thallium atoms.

The transfer of energy in general will only occur if the energy of excitation of one atom exceeds that of the other. The residue of the energy not used in excitation is transferred into kinetic energy of the two systems involved. Such a type of transfer of energy from an excited to a neutral atom is no doubt of great importance in the study of photo-electric reactions and of chemical combination generally.

We shall now turn our attention to the atomic nucleus, and see how far the processes considered for the outer electronic system are applicable. We know that the nucleus of an atom has a resultant positive harge but still contains negatively charged electrons It is generally supposed that the two fundamental units in nuclear structure are the proton of mass very nearly one, and the electron. The proton in the free state is believed to be the hydrogen nucleus which has a unit positive charge. Since the main part of the mass of an atom is concentrated in the nucleus we can at once deduce from the atomic mass of the atom and its nuclear charge, the actual number of protons and electrons in the nucleus. For example, the heaviest element uranium of charge 92 and mass 238 probably contains 238 protons and 146 electrons. The nucleus of even a heavy atom like uranium is of very small dimensions and if it be assumed spherical in shape, its radius cannot be much greater than 7×10^{-12} cms. In this small space is concentrated this large number of protons and electrons which must be held in equilibrium by their mutual forces. It is evident therefore, that the density of distribution of both protons and electrons in the nucleus is very high compared with that of the outer electrons which fill a sphere of radius about 2×10^{-8} cms. or about 300 times greater than that of the nucleus. It is, of course, probable that the protons and electrons in a heavy nucleus are not all independent units of its structure. We have good reason for believing that the helium nucleus, containing 4 protons and 2 electrons, is one of the secondary building units while it is not unlikely that other nuclear combinations may be possible.

We know that the atoms of the radioactive elements are unstable and break up occasionally with explosive violence either with the expulsion of an α particle or a swift electron from the nucleus. The processes occurring in such an exploding atom are in many respects very different from those observed in the outer electronic system. In the first place, it is important to remember that the radioactive processes are irreversible. The nucleus which has lost an α

particle or electron is not reformed by the addition of a positively charged particle or electron from outside, but a new atom results of different atomic number and of different physical and chemical properties. In this respect the nucleus is completely differentiated from the outer electronic system where the atom is rapidly reorganised even if it has lost a number of its electrons. There is no evidence that the electron can fall from the outside into a nucleus, for if this were so the material, for example, composing the electrodes of a vacuum tube would be rapidly transformed. Notwithstanding claims to the contrary, it seems to me very improbable that under ordinary laboratory conditions the nuclei of atoms can be changed in this way, or we should long ago have observed definite evidence of such transformation.

In other respects, the contrast between the electronic system and the radioactive nucleus is very marked. The nucleus expels not only electrons but actual atomic masses and the energy of their expulsion is in most cases enormous compared with the energy capable of being released from an excited atom. In addition the frequency of the penetrating γ rays emitted by some radioelements is very great compared with that of the K-radiation of an element, in some cases corresponding to an energy of about 3 million volts.

In one direction, however, there may prove to be a close analogy between the processes occurring in the nucleus and outer atom. In recent years, the wavelengths of the penetrating γ rays from radioactive substances have been measured and Ellis has shown that the energies of the γ rays emitted from both radium B and radium C show those combination differences which are so characteristic of the Bohr energy levels in an excited atom. It is thus natural to suppose that the emission of penetrating γ rays like ordinary X-rays is due to transitions between stationary states in the radium B or radium C nucleus, and a simple system of energy levels can be deduced to fit in a number of the γ rays observed. It is, however, not yet certain whether the emission of γ rays is due to the transfer of an electron or an α particle from one level to another.

If these conclusions are correct, it indicates that the quantum dynamics apply to the nucleus as well as to the outer atom. Unfortunately, we are as yet ignorant of the exact laws of force that hold between the protons and electrons which are packed so close together in the minute nucleus and so are not in a position to determine what quantum orbits are theoretically possible.

In view of this conclusion, it is somewhat surprising that we have not been able to find any certain evidence that the nuclear electrons, which for a heavy atom exceed in number the planetary electrons, play any obvious part in the absorption of the most penetrating γ rays. As far as experiment has gone, the scattering and absorption of γ rays is due very largely if not entirely to the planetary electrons. It may be that the majority of the electrons in the nucleus are so tightly bound in various combining units that they no longer act like the comparatively loosely bound electrons of the outer atom.

In conclusion a few words should be said about the origin of the energy liberated from radioactive atoms in the form of the α, β, and γ rays. On present views of nuclear structure, it seems clear that a considerable part of the energy of the α particles emitted by radioactive substances—probably more than half—is acquired in escaping through the powerful repulsive field of the nucleus. On the other hand, a β particle to be ejected from the nucleus, must be endowed with much greater energy than we observe, for it is attracted back to the nucleus. The γ rays of course, are quite unaffected in energy in escaping from the atom, provided they are not scattered by the electrons.

It has been suggested that the nucleus of a radioactive atom like that of uranium is analogous to an "excited" atom where an electron is displaced to a level of higher energy On this view, the units of the nuclear structure have not all arranged themselves in positions of ultimate equilibrium but still have a surplus energy which is released in the form of the characteristic radiations from active matter. Since, however, uranium has a radioactive life of about 7,000 million years, it is clear that the life of an excited nucleus is in some cases enormous compared with the life, for example, of an excited hydrogen atom. On this view the primary radioactive elements, uranium and thorium, are sole survivors on the earth today of types of atoms that were common in long distant ages when the atoms now composing the earth were in course of formation.

On our present views of nuclear structure, it seems fairly certain that energy must be expended to remove the protons and electrons composing a nucleus to a great distance from each other. This, however, does not exclude the possibilty that energy may be derived from *some* atoms by removal of one or more of the parts of the nucleus. Suppose, for example, as seems not improbable, that the heavier nuclei are composed in part of satellites in the form of α particles or protons which are held in equilibrium by a resultant attractive force from the main nucleus. By suitable agencies, it may be possible by the expenditure of energy to make the satellite unstable and to remove it from the attractive field close to the nucleus to the region where the forces are repulsive. In escaping from the atom, the satellite may acquire more kinetic energy in the repulsive field than was required to upset its equilibrium. Energy may in some cases be gained as a result, although such a process may only be possible for a few units of the nucleus which exist in satellite form.

This may be illustrated by the results obtained by Dr. Chadwick and myself in the study of the artificial disintegration of an aluminium nucleus by bombardment with swift α particles. In a small fraction of the cases where disintegration occurs, a proton is liberated with energy even greater than that of the colliding α particle, so there is on the whole a measurable gain of energy in the disintegration process. Further light has recently been thrown on this question by the experiments of Blackett, who has obtained by the Wilson method a number of photographs showing the trails of the particles when a nitrogen nucleus is disintegrated by a close collision with an α particle. In these photographs, only the liberated proton and recoiling nucleus are visible after the collision.

This suggests that the α particle is captured by the nitrogen nucleus while the latter loses one of its constituent protons. It is not unlikely that a similar result may hold in this case of aluminium so that the gain of energy referred to comes rather from the building up of a heavier atom than from its disintegration into a lighter one.

Deductions of this kind must of necessity be rather speculative until we have more definite knowledge of the detailed structure of the nucleus and of the nature of the forces that hold it together. In a sense, the minute nucleus of an atom is a world of its own, of which we know very little, but there are at present a number of modes of attack which may add much to our knowledge in the near future.

DISCUSSION.

The Chairman, in moving a very hearty vote of thanks to the Lecturer for his admirable discourse, said he had to confess that he felt very unworthy to do such a thing, as he was afraid that he could not personally discuss to any advantage the wonderful lecture which had just been delivered; but he had great pleasure in calling upon Sir Oliver Lodge to second the motion, in the hope that he would be able to perform the function more worthily than he himself was able to do.

Sir Oliver Lodge, F.R.S., said before he seconded the vote of thanks he thought the meeting would wish him to announce a sad item of information which had just reached him, namely, the death that day of Mr. Oliver Heaviside, a great mathematician and one who had elaborated the theory of cable signalling; one who had given the theory of electric waves in many complete forms, and one whose work was of an extraordinarily brilliant character, though having personal characteristics which did not make it acceptable at once. Mr. Heaviside had lived the life of a recluse, and he had died very sorrowfully in Devonshire in a nursing home, but looked after with affectionate piety by Dr. Searle, of Cambridge, who had gone down to take care of him; otherwise he would have been quite alone.

He was very glad indeed to second the vote of thanks to Sir Ernest Rutherford. The subject of the lecture was so large that he did not know where to take it up. The fact was that a great deal of what Sir Ernest had been saying about the outside parts of the atom, although very interesting in itself, had been almost put out of his mind by the extraordinarily interesting light which Sir Ernest was beginning to throw upon the nucleus. Sir J. J. Thomson had discovered the electron, and he thought it was fair to say that his successor, Sir Ernest Rutherford, had discovered the nucleus. Sir Ernest had not yet told them much about it; there was a lot more to know about it. It was the most interesting thing in physics at the present time. Sir Ernest was a young man in full vigour, and long after he (Sir Oliver) had gone, he would be telling the world a great deal more about it. Meanwhile, Sir Ernest had begun. He had begun by disintegrating, and he now, from his words that evening, seemed to be building it up again; but whether he had understood Sir Ernest correctly or not, he was not quite sure. Sir Ernest bombarded the nucleus with an alpha particle which was a charged helion atom with atomic weight 4; he threw out of it a proton which was a charged hydrogen atom with atomic weight 1. He had never told anyone before what happened to that helion atom. He now said it came in, and was captured. If one put in 4 and took out 1, there were 3 left. If so, Sir Ernest had begun to build up the atomic weight, and that is what scientists had been wanting to do for years. There had been spontaneous disintegration ever since Madame Curie had discovered radium, indeed ever since uranium had been discovered, but no one had ever been able to build up. Yet something must have built them up. Perhaps it was in the interior of hot stars that the chemical elements were being formed, while we only saw them going down again. Were they going up in Rutherford's laboratory ? He did not know, but his audience would see the importance of what was going on. They had in Sir Ernest the man who really started this kind of astronomy of the atom—the astronomical atom. He showed that the law of inverse square was obeyed by those planetary electrons, and thereby the whole dynamics of Sir Isaac Newton became applicable to the atom. Sir Ernest now seemed to be beginning to detect law and order, perhaps similar law and order, in the crowded nucleus, where protons and electrons were jammed together into a very small space. He believed Sir Ernest thought the proton was smaller than the electron. There were reasons for supposing it was ; though he himself had a reason for saying that the proton was 7½ times the diameter of the electron. That all showed how little was known about it. Those measurements had to be made. Was it not remarkable the insight that was being obtained into the interior of what used to be thought in his youth the smallest possible particle ? How could it be anything but a sort of Euclidean point without parts and without magnitude ? But it had law and order ; it had a system, and it obeyed laws. Those laws, expounded by Bohr, who had begun his work in Rutherford's laboratory at Manchester, and who was now one of the greatest scientists of the time, gave the theory of the spectrum. Anyone who looked at a photographic spectrum would see how complicated it was, and might well wonder how to interpret it. Yet a great deal of accurate law had emerged from Bohr's system. They were analysed specially at South Kensington by Professor A. Fowler, and he hoped Sir Alfred Yarrow, who was present in the audience, was pleased with the work which was being done by those research professors whom he had endowed.

He had said enough to show that the meeting had been privileged to be introduced to the latest development of this remarkable investigation characteristic of the present century—an investigation which was only one of several great pieces of work at present going on in physics, and which gave opportunities for discoveries that were rousing keen enthusiasm not only among younger physicists, but also to a large extent among the educated public.

LA VIE INDUSTRIELLE EN FRANCE.

Le IX° Salon de l'Aeronautique, a Paris.

Le Salon de l'Aéronautique vient de se tenir à Paris, au Grand-Palais des Champs-Elysées, du 5 au 21 décembre, et on a pu y juger des progrès récents de la construction. Les participants étrangers étaient très peu nombreux : une firme anglaise (Armstrong Siddeley) et trois hollandaises, mais les constructeurs français ont exposé en grand nombre des avions de toute catégorie, des moteurs puissants, et deux petits dirigeables.

Les recherches se sont portées sur l'augmentation de vitesse (on a atteint récemment près de 400 kilomètres-heure), sur l'accroissement de la charge utile et la réduction de la puissance. Au point de vue constructif, on abandonne de plus en plus le bois pour en venir à la construction entièrement métallique, partie en acier, partie en alliages légers : duralumin, alférium, etc. Les hélices

métalliques elles-mêmes semblent s'imposer à l'attention : les maisons Nieuport et Chauvière en fabriquent déjà.

Les études d'aérodynamique se poursuivent activement dans les centres de recherches officiels, à Paris (laboratoire Eiffel, appartenant aujourd'hui à l'Etat), à St. Cyr et à Issy-les-Moulineaux, tous trois pourvus de souffleries et de tunnels capables de recevoir des modèles d'avions réduits et même certains éléments en grandeur d'exécution, pour les mesures à la balance aérodynamique. Ces centres d'études sont précieux pour la détermination des qualités des profils d'ailes, épais et semi-épais, pour la mise en évidence de l'influence de la disposition des voilures les unes par rapport aux autres, pour la recherche des conditions de rendement optimum des hélices montées en tandem, etc.

Nous ne pouvons que mentionner ici très rapidement, parmi beaucoup d'autres, quelques avions particulièrement remarqués au Salon. C'est d'abord le Bréguet, type XIX, modèle de l'avion du Capitaine Pelletier d'Oisy pour la première partie de son voyage Paris-Tokyo. Ce biplan comporte un moteur Lorraine-Diétrich de 400 h.p. ou un moteur Renault de 480 h.p.

Citons encore les avions de chasse Dewoitine et Nieuport-Delage, les avions de transport commercial Blériot, les avions d'école et de tourisme Caudron, les hydravions Latham et Cams, les avions de bombardement Farman et Lioré-Olivier les monoplans Morane-Saulnier, type "Parasol," enfin le grand monoplan à deux moteurs des Etablissements Schneider.

Les constructeurs de moteurs bien connus, Farman, Lorraine-Dietrich, Renault, Salmson, ont exposé de nouveaux modèles dont l'endurance devient de plus en plus grande. Il ne faut pas oublier, en effet, que les moteurs sont l'organe vital de l'avion, et que leur révision périodique à courts intervalles, coûtant fort cher, grève lourdement le prix de revient de la tonne kilométrique transportée.

Les Turbines a Explosion pour l'Aeronautique.

La question des turbines à explosion, à gaz ou à pétrole, est étudiée en France depuis plusieurs années. Elle a fait des progrès suffisants pour que le Service Technique de l'Aéronautique ait pu passer récemment, à trois constructeurs, des commandes de turbines à essence destinées à être essayées sur des avions. Ces moteurs sont destinés, en principe, à permettre des vols très rapides aux altitudes élevées.

Les plus importantes de ces nouvelles machines sont les turbines Odier, dont trois unités de 300 h.p. chacune ont été commandées.

La turbine à explosion comporte un compresseur remplissant d'air comprimé et d'essence pulvérisée, une chambre que l'on allume. Les gaz s'échappent par un orifice en forme de tuyère, qui les dirige sur le rotor de la turbine, du type à action. La turbine Odier, perfectionnée par plus de deux années de recherches, fonctionne à 2,000 ou 2,200 explosions par minute, sans échauffement excessif ; les fuites sont très faibles et les gaz résiduels sont évacués à une pression légèrement inférieure à la pression atmosphérique.

Plusieurs chambres d'explosion ont déjà fonctionné pendant plus de 200 heures sans usure sensible.

Contrairement à ce qui a lieu pour les moteurs à pistons, le rendement est augmenté en retardant l'allumage.

Le compresseur aspire dans le carburateur, de sorte que c'est l'air carburé qui est comprimé directement dans la chambre de compression. Les tuyères qui dirigent les gaz de l'explosion, taillées dans la masse, sont en acier rapide. Les ailettes du rotor sont formées de disques lenticulaires d'égale résistance, à la périphérie desquels sont encastrées des ailettes fraisées ; ces ailettes prennent, au fonctionnement, un poli remarquable.

Les essais des premières turbines Odier ont donné des résultats très intéressants. Les détails de construction en sont tenus secrets jusqu'ici, mais on compte que ces moteurs auront surtout un très bon rendement aux hautes altitudes, et qu'ils permettront d'élever sensiblement le " plafond " des avions actuels.

Un nouvel Alliage leger pour les Constructions Mecaniques, l'Alferium.

Les alliages d'aluminium et ceux de magnésium, les premiers surtout, ont déjà conquis une place de premier ordre dans les constructions automobile et aéronautique. Le plus ancien et le plus connu est le duralumin, aujourd'hui employé à l'état laminé ou estampé, pour constituer, par exemple, l'ossature des dirigeables Zeppelin, ou des ailes et des cellules d'avions.

L'alpax, beaucoup plus récent, est un autre alliage d'aluminium à 13% de silicium, qui s'emploie fondu, et rend pour les pièces moulées (carters, roues, etc.), les mêmes services que le duralumin.

Un nouveau venu dans la même famille est l'alférium, alliage à base d'aluminium et de cuivre, fabriqué par les usines du Creusot. Voici quelques détails sur les qualités physiques et mécaniques de ce nouveau métal.

Au dernier stade de sa fabrication, il est chauffé vers 500°, puis trempé à l'eau ; il est alors relativement doux, mais il durcit de lui-même pendant quelques jours (c'est ce qu'on appelle le vieillissement) et, au bout d'une semaine environ, il a atteint définitivement les caractéristiques suivantes :

Limite élastique :	22 à 28 kgs par m/m^2
Résistance :	36 à 42 kgs par m/m^2
Allongement :	14 à 22%
Module d'élasticité :	7,500
Densité :	2.8
Point de fusion :	640° C.
Coefficient de dilatation linéaire :	22.6×10^{-6}
Chaleur spécifique :	0.22

Son usinage à froid est facile ; son travail à chaud doit se faire aux environs de 400°, sinon le métal est sujet à se fissurer.

L'alférium, d'aspect blanc argenté, résiste bien à l'humidité ; cependant, il est préférable de le protéger par un vernis. Il est peu sensible aux acides, mais très attaquable par la soude et la potasse.

Dans l'humidité, l'alférium se corrode au contact de l'acier, et plus légèrement au contact des métaux cuivreux. Pour l'assemblage des pièces d'alférium, on doit donc employer des rivets en alférium, de préférence aux rivets en cuivre et surtout aux rivets en acier.

Ce métal, actuellement fourni à l'état de tôles, tubes, barres et profilés, est utilisé dans l'aviation, dans l'automobile, dans les chemins de fer et tramways, dans l'artillerie, etc.

Nouvelles Lignes de Chemins de fer desservant des Mines de fer en Algerie.

On vient d'inaugurer, le 15 décembre, une nouvelle ligne du réseau algérien qui descend de Tlemcen, sous-préfecture du département d'Oran, jusqu'au port de Beni-Saf, sur une longueur de 60 kilomètres (38 miles). Cette ligne comporte deux ponts importants sur la Tafna.

D'autre part, on étudie une ligne devant relier Sétif, sous préfecture du département de Constantine, au port de Bougie, en traversant une région montagneuse de la Petite Kabylie, dont les richesses minières et forestières sont inexploitées, faute de débouchés.

A mesure que la construction de la ligne avancera, elle permettra d'exploiter les mines de fer échelonnées sur son parcours, qui lui fourniront aussitôt des éléments de trafic.

DEVELOPMENT OF FRENCH WATER-POWER RESOURCES.

(*Concluded from page* 384.)

The Rhine is really the only river in the fourth area for which schemes have materialised, and even on this river work is concentrated on one station—at Kembs (80,000 h.p.); seven other works (with a total horse-power of 720,000) between Bâle and Strasbourg are planned. Progress has been made and the Alsatian electrical companies are already planning the lines to take the force produced by the station. Apart from this scheme, the only project of any importance is the rumoured harnessing of the Weiss.

Outside the four main districts development on a much smaller scale has been proceeding. In Brittany a new station is being erected at Guerledan on the Blavet. A reservoir with a capacity of 50 million cubic metres is being constructed, and the voltage of the lines from the station will be from 15,000 to 45,000 volts. In general, outside these regions, and especially in the Northern Area, the large schemes put into operation since 1919 have been based on the utilisation of coal for electricity production.

The plans for the execution of the first tidal-power station in the world, namely that at Aber-Wrach (24 miles by light railway from Brest, the point of the barrage being three miles up the Aber-Wrach estuary) have all been completed, but the necessary capital for proceeding with its construction has not yet been secured. The Aber-Wrach station takes the form of a barrage of 150 metres in length and from 12 to 24 metres broad, composed of three caissons in reinforced concrete with four groups of turbines working under the double effect of the tide (the depth at barrage and for about a kilometre higher up is 12 to 15 metres) and ebb-tide the power obtained would vary from 75 to 1,200 h.p. In the central caisson (34 metres long, 26 metres high, and 24 metres broad) will be placed the turbines; there will be two alternators furnishing a current of 1,500 volts. The length of the three caissons will be 70 metres. Following the usual Swiss practice, there will be provided a boat lift 10 metres broad to allow of the passage of boats and dredgers. The second barrage will be a station utilising the fresh water of a stream named the Diouris, which flows into the estuary of the Aber-Wrach. This barrage will be 30 metres high, allowing the storage of 12,000,000 metric cubes of fresh water, with a fall varying from 8 to 29 metres. This establishment will have as its object to regulate the intermittent electric power producible by the tidal station, and more particularly to accumulate water for providing power during the twenty to thirty minutes at the turn of the tide when the latter is more or less quiescent. The two concerns will work in close liaison with each other and give a continuous minimum power of 1,600 h.p. and a maximum power of 3,200 h.p. Annual production would thus amount to 11,000,000 kilowatt hours, corresponding to an economy of 16,500 tons of coal per annum. Brest would be supplied by a transmission line of 30,000 volts. State support for the whole scheme received the approval of the Senate on 23rd December 1923, but the financial amount to be contributed to the estimated cost of 20,000,000 francs (at 1921 prices) has not yet been voted. If the Aber-Wrach station proves a success, it is probable that a similar station will be constructed in the future in the estuary of the Rance (which runs from Dinan to St. Malo): it is estimated to yield 300 to 400,000 h.p. or 220,000 kilowatts. A Brest roadstead scheme has also been mooted.

GENERAL NOTE.

TATTOOING LARGE BLACK PIGS.—The Scientific Research Committee of the Large Black Pig Society, 12, Hanover Square, London, W. 1, has devoted considerable attention to the question of the tattooing of the large black pigs. At the present time, there are two systems of marking pigs, namely, by means of notching the ear, or by the insertion of ribbons containing numbers. Neither is quite satisfactory, as these systems do not provide any guarantee against dishonesty, such as would be obtained if a proper tattooing system could be devised. It is quite simple to tattoo white pigs; but with regard to the black pigs the difficulty arises from the colour. Tattooing or marking is always carried out in the ears, and what the Large Black Pig Society particularly want is a tattooing ink which can be applied by ordinary tattooing instruments and which will leave a permanent record in the ear. The Scientific Committee of the Large Black Pig Society have recommended that substantial prizes should be offered to competitors who submit any scheme for the tattooing of large black pigs which will have the particular characteristic desired by the Society, namely, permanency.

MEETINGS OF THE SOCIETY TO APRIL 29, 1925.

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ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock, unless otherwise announced:—

MARCH 18.—CLAUDE H. FRIESE-GREENE, "The Friese-Greene Process of Colour Cinematography." (Illustrated by films in natural colours). J. DUDLEY JOHNSTONE, President, Royal Photographic Society, will preside.

MARCH 25.—HENRY G. DOWLING, "Wall-papers."

APRIL 1.—WILLIAM NUNN, "Siam: its Prospects and Possibilities."

APRIL 22.—CEDRIC CHIVERS, "Bookbinding." J. M. DENT will preside.

APRIL 29.—LIEUT.-COLONEL ANDREW BALFOUR, C.B., C.M.G., M.D. (Edin.), B.Sc., D.P.H., F.R.C.P.E., "The Trend of Modern Hygiene."

DOMINIONS AND COLONIES AND INDIAN SECTIONS. (JOINT MEETING.)

THURSDAY, APRIL 16 (4.30 p.m.)—LORD STEVENSON, G.C.M.G., "The British Empire Exhibition. SIR CHARLES CAMPBELL MCLEOD, Bt., will preside.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

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MONDAY, MARCH 16..Geographical Society, Kensington Gore, S.W. 5 p.m. Mr. R. D. Oldham, "The Portolan Maps of the Rhone Delta."

British Architects, Royal Institute of, 9, Conduit Street, W. 8 p.m. Mr. F. R. Hiorns, "The Corporate Spirit in Architecture."

Textile Institute, at the Clothworkers' Hall, 41, Mincing Lane, E.C. 5.45 p.m. Prof. A. F. Barker, "Fashions and Fabrics."

Electrical Engineers, Institution of (Local Centre), at The University, Liverpool. 7 p.m. Discussion on "The Applications of Electricity on Board Ship."

Swiney Lecture, at King's College, Strand, W.C. 5.30 p.m. Dr. W. T. Gordon, "The Geological History of Plants." (Lecture VII.)

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. A. E. Richardson, "Bridges and Designs for Bridges," at the London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. Prof. A. E. Janssen, "The Restoration of Belgian Public Finance."

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Prof. P. Lehmann, "Anglo-German Script in the Germany of the Middle Ages." (Lecture II.)

City of London College, White Street, Moorfields, E.C. 5.30 p.m. Dr. E. Wendler, "Commercial Developments in Germany."

TUESDAY, MARCH 17..Statistical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 5.15 p.m. Mr. C. W. Hurcomb, "Official Railway Statistics in Great Britain."

Mineralogical Society, at the Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

Marine Engineers, 85, The Minories, E. 6.30 p.m. Mr. A. C. Hardy, "Motor Passenger Vessels."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Annual General Meeting of the Scientific and Technical Group."

Roman Studies, Society for the Promotion of, at the Society of Antiquaries, Burlington House, Piccadilly, W. 4.30 p.m. Mr. S. E. Winbolt, "The Brito-Roman Site at Folkestone."

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. E. N. da C. Andrade, "The Evolution of the Scientific Instrument." (Lecture II.)

Electrical Engineers, Institution of, (N. Western Centre), at the Engineers' Club, Albert Square, Manchester. 7 p.m. Colonel T. F. Purves, "The Post Office and Automatic Telephones."

Transport, Institute of, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C. 5.30 p.m. Mr. A. E. Kirkus, "Some Practical Statistical Units."

Automobile Engineers, Institution of, at the Engineering and Scientific Club, Wolverhampton. 7.30 p.m. Mr. A. F. Burstall, "Experiments on the Power and Efficiency of a High Speed Gas Engine."

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. A. C. Seward, "Botany." (Lecture I.)

5.30 p.m. Mr. C. D. Forde, "The Megalithic Monuments of Brittany."

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia from 1861." (Lecture IX.)

At the London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. Sir Daniel Hall, "The Factors which limit the Development of Food Production in Great Britain." (Lecture I.)

WEDNESDAY, MARCH 18. . Cold Storage and Ice Association, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 5.30 p.m. Dr. E. Griffiths and Mr. J. H. Awbery, "Small Refrigerating Plants and the Thermodynamical Properties of Refrigerating Liquids."

Entomological Society, 41, Queen's Gate, S.W. 8 p.m.

Geologists' Association, University College, Gower Street, W.C. 7.30 p.m. Discussion on the "Recording of Temporary Sections in the London Area." (1) Prof. H. L. Hawkins, "Work for All." (2) Mr. H. B. Milner, "The Intensive Study of Sediments." (3) Mr. S. W. Wooldridge, "Some Gaps in our Knowledge of London Geology."

Swiney Lecture, at King's College, Strand, W.C. 5.30 p.m. Dr. W. T. Gordon, "The Geological History of Plants." (Lecture VIII.)

Meteorological Society, 49, Cromwell Road, S.W. 7.30 p.m. (1) Sir Napier Shaw and Mr. H. Fahmy, "The energy of saturated air in a natural environment." (2) Mr. C. K. M. Douglas, "On the relation between the source of the air and the upper air temperature up to the base of the stratosphere." (3) Mr. A. H. R. Goldie, "Waves at an approximately horizontal surface of discontinuity in the atmosphere."

Electrical Engineers, Institution of, (Sub-Centre), in the Mappin Hall, St. George's Square, Sheffield. 7.30 p.m. Mr. G. F. Jones, "Some Considerations in the Design, Manufacture and Testing of Broadcast Wireless Receiving Apparatus."

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. T. B. Wood, "The Nutrition of the Young Animal." (Lecture III.)

At King's College, Strand, W.C. 5.30 p.m. Prof. J. D. Wilson, "Education and Industrial Democracy."

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Prof. P. Lehmann, "Anglo-German Script in the Germany of the Early Middle Ages." (Lecture II.)

At the London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. Mr. B. Campion, "The Banker and the Law."

THURSDAY, MARCH 19. . Aeronautical Society, 7, Albemarle Street, W. 5.30 p.m. Capt. F. Tymms, "Practical Navigation of Aircraft."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. Mr. S. Evershed, "Permanent Magnets in Theory and Practice."

Child Study Society, 90, Buckingham Palace Road, S.W. 6 p.m. Comdr. B. T. Coote, "What the Miners' Welfare Fund is doing for Children and Young People in Mining Communities."

Chemical Society, Burlington House, Piccadilly, W. 8 p.m. Messrs. D. H. Bangham and J. Stafford, "The 'activation' of graphite as a sorbent of oxygen."

Linnean Society, Burlington House, Piccadilly, W. 5 p.m. (1) Mr. A. S. Hirst, "Parasitic Mites on Lizards." (2) Mr. W. R. B. Oliver, "Bio-geographical Relations of the New Zealand Region." (3) Mrs. M. Roach, "A Study of the Physiology of Certain Soil Algæ in Pure Culture."

Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p.m.

Royal Institution, Albemarle Street, W. 5.15 p.m. Dr. L. Hill, "The Biological Action of Light." (Lecture II.)

Victoria and Albert Museum, South Kensington, S.W. 6 p.m. Mr. E. W. Tristram, "English Wall Paintings."

London County Council, at the Geffrye Museum, Kingsland Road, E. 7.30 p.m. Mr. I. C. Goodison, "Some Masterpieces of the English Cabinetmakers."

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

Mechanical Engineers, Institution of, (Midland Branch), at the Queen's Hotel, Birmingham. 6.30 p.m. Mr. J. W. Hall, "The Engineer's Prospect after 1815 and 1918."

University of London, at King's College, Strand, W.C. 5.30 p.m. Dr. A. R. Pastor, "Spanish Saints and Heretics." (Lecture IV.)

6.30 p.m. Dr. O. Vocadlo, "Czech Civilisation." (Lecture X.)

At the London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. Sir Daniel Hall, "The Factors which limit the Development of Food Production in Great Britain." (Lecture II.)

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Prince D. S. Mirsky, "Russian Literature in the Second Half of the Nineteenth Century." (Lecture IX.)

FRIDAY, MARCH 20. . London County Council, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 6.30 p.m. "Modern Movements in Education." (Lecture I.)

Royal Institution, Albemarle Street, W. 9 p.m. Prof. J. W. McBain, "Soaps and the Theory of Colloids."

Transport, Institute of, (N. Western Section), Manchester. Mr. F. Searle, "Air Transport."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 6 p.m. Report of the Marine Oil-Engine Trials Committee.

Engineers, Junior Institution of, 39, Victoria Street, S.W. 7.30 p.m. Mr. S. H. Hole, "Modern Transport."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Address to the Pictorial Group by Mr. F. C. Tilney.

University of London, King's College, Strand, W.C. 5.30 p.m. Baron A. F Meyendorff, "The Russian Church, Past and Present." (Lecture III.)

Eugenics Education Society, at the Royal Society, Burlington House, Piccadilly, W. 5 p.m. Dr. J. Brownlee, "The Present Tendencies of Population in Great Britain in respect to Quality and Quantity."

Central Asian Society, at the Royal United Service Institution, Whitehall, S.W. 5 p.m. Mr. C. P. Skrine, "The Roads to Kashgar."

Textile Institute, at the Overlookers' Hall, High Street, Blackburn. 7.30 p.m. Sir W. Clare Lees, "The Economic Situation of Europe as it affects the Cotton Trade of Lancashire." (Joint meeting with Blackburn Textile Society.)

SATURDAY, MARCH 21. . Royal Institution, Albemarle Street, W. 3 p.m. Prof. Sir Ernest Rutherford, "The Counting of the Atoms." (Lecture IV.)

London County Council, at the Horniman Museum, Forest Hill. S.E. 3.30 p.m. Mr. S. H. Warren, "Who were the first Men?"

Chadwick Public Lecture, University College, Gower Street, W.C. 3 p.m. Dr. W. M. Feldman, "Post-Natal Child Physiology and Hygiene."

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

WEDNESDAY, MARCH 25TH, at 8 p.m. (Ordinary Meeting.) HENRY G. DOWLING, Chief Decorative Adviser, Messrs John Line & Sons, "Wall-papers."

COUNCIL.

A meeting of the Council was held on Monday, March 9th. Present:—Mr. Alan A. Campbell Swinton, F.R.S., in the Chair; Sir Charles H. Armstrong; Sir Frank Baines, C.V.O., C.B.E.; Rear-Admiral James de Courcy Hamilton, M.V.O.; Mr. P. M. Evans, M.A., LL.D.; Sir Edward A. Gait, K.C.S.I., C.I.E.; Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.; Mr. Carmichael Thomas; Mr. J. Augustus Voelcker, M.A., Ph.D.; and Sir Frank Warner, K.B.E., with Mr. G. K. Menzies, M.A. (Secretary of the Society) and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

Sir Charles S. Bayley, G.C.I.E., K.C.S.I., was appointed a Vice-President of the Society in place of Lord Blyth, deceased.

Sir Humphrey Leggett, D.S.O., R.E., was appointed Chairman of the Dominions and Colonies Section Committee in place of Lord Blyth, deceased.

The question of the award of the Albert Medal for 1925 was further considered.

A report of the Examinations Committee on the Syllabuses in Commercial Correspondence and Business Knowledge was approved.

Delegates were appointed to represent the Society at a Conference convened by the Royal Microscopical Society at the University of Sheffield in April, and at the World Conference of Education Associations to be held in Edinburgh in July.

Other formal business was transacted.

FOURTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 11TH, 1925. VISCOUNT BURNHAM, C.H., LL.D., in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Brown, Percival, Barnsley, Yorks.
Elliott, William Ebenezer, Wallasey, Cheshire.
Goodman, William Henry, London.
Harding, Walter, Noctorum, Cheshire.
Knowles, Professor Lilian C. A., Litt.D., London.
Morren, Percy John, St. Leonards-on-Sea, Sussex.
O'Conor, The Hon. Broughton B., M.L.C., Sydney, Australia.
Shastri, Hirananda, M.A., Ootacamund, India.
Strang, Robert Winning, Kilmacolm, Renfrewshire.

The following candidates were duly elected Fellows of the Society :—

Banner, Edgar Harold Walter, M.Sc., Wembley, Middlesex.
Binns, Arthur, Keighley, Yorks.
Burton, Montague, Leeds.
Davidson, John, Edinburgh.
Lockwood, Crosby, M.C., M.A., London.
Lowe, G. C. T., Liverpool.
Minnikin, George Rennison, Windermere, Westmorland.
Priestley, James Nicholl, St. Anne's-on-the-Sea, Lancs.
Rutt, Harold Alfred, London.
Trigge, Joseph Edward, Croydon.

A paper on "The Restoration of Belgian Towns" was read by M. EMILE CAMMAERTS.

On the motion of H. E. THE BELGIAN AMBASSADOR (Baron Moncheur), seconded by LORD BURNHAM, a vote of thanks to M. Cammaerts was unanimously passed.

The paper and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

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INDIAN SECTION.

FRIDAY, FEBRUARY 6TH, 1925.

SIR EDWARD A. GAIT, K.C.S.I., C.I.E., Ph.D., in the Chair.

THE CHAIRMAN said that the author needed no introduction to the members present. Two years ago he contributed a very interesting paper on the Indian census of 1921. On the present occasion he was going to deal with the problems suggested by a consideration of the census figures from a somewhat wider point of view. Mr. Marten at that moment was on his way to India, and Mr. H. R. Crosthwaite, C.I.E., C.B.E., had kindly consented to read the paper.

The paper read was :—

POPULATION PROBLEMS FROM THE INDIAN CENSUS.

By J. T. Marten, M.A., I.C.S., Census Commissioner for India.

Introduction.

In a paper which was read before this Society on the 23rd February, 1923, I attempted to give some account of the conditions under which the census of 1921 was taken in India, and some of the difficulties which were encountered, and successfully overcome. I also briefly set out some of the most important of the statistics of population in the chief categories of region and religion, and gave an indication of the influences which determined the movements of population indicated by the figures. Since that date the full results of the Census have been published in the official Census Series, and the statistics and reports which appear there are available for study by those interested. I do not propose on the present occasion to deluge you with figures, but rather to draw attention to some of what seem to me the most important problems which emerge from the statistical matter collected in these reports.

Growth of Population.

2. The population of India as a whole and, with the exception of Assam and some few concentrated industrial areas, of the administrative units—the Provinces and States—is self-contained. Migration is small and quantitatively unimportant. The population grows by natural reproduction, the chief characteristics of this growth being a high birth rate, owing chiefly to the universality of marriage, and a correspondingly high death rate, a large proportion of which represents infant mortality. The measure of progress, *i.e.*, the difference between the birth and death rates, is not greater than that of many countries of Europe and may, perhaps, be estimated at a normal of 7 or 8 per cent. in a decade. It would be interesting if we could arrive at some definite estimate of the factors which govern the standards of growth and the periodical fluctuations from them. The official birth and death rates are too incomplete and imperfect to be of much use, and they do not classify the community in different social and economic strata. It is frequently stated that the variations in the "economic" circumstances of the people, due to good and bad harvests, form the principal factors in determining the variations in the birth and death rates. A confusion arises from the use of the word economic. In its wider sense, *i.e.*, as referring to all the conditions and circumstances of a " household," social, traditional, material and domestic, the word expresses somewhat the same idea as that contained in the expression " standard of life." But it is easy to slip from the wider to the more restricted use of the word, as implying merely the financial and material resources of living, and this is where I think that a very popular fallacy arises. In India, as in every other country, the most prolific portion of

the population is at the lowest stratum, and modern theories incline to the view that a maximum fertility is associated with a simplicity of life, which usually includes a minimum subsistence diet, and that fertility automatically declines as life becomes more complex, more luxurious, more individualised and more subject to nervous strain. This economic simplicity of living in the larger portion of the Indian population, along with the custom of universal marriage, has given India a high average birth rate. Diseases, due to climate and physical conditions, combined with the non-hygienic customs and traditions of the people and their ignorance and indifference to maternal and infant welfare, lessen their resistance to disease and keep up the level of the death rate. These are the constants which regulate the vital standards and which can change only slowly with the progress of education and social culture and with the improvement of the environment. Of the fluctuating influences which determine the periodical variations from the average the most important, if we except catastrophic years of famine, is the direct effect of climate on health and not, I think, the smaller variations in the material conditions of the people. In the matter of housing, clothing and diet the lowest strata of the Indian people are probably not worse off than the slum population of Western towns, taking into consideration the differences of climate; and Mr. Calvert, in his interesting book, "The Wealth and Welfare of the Punjab," is able to show that the average Punjab peasant lives at a standard of life which is distinctly above that of a large portion of the peasantry in southern and eastern Europe. It has usually been held that high prices are accompanied by a high death rate, but the Health Officer of Bengal has recently shown that the opposite is the case. Dr. Mann, in his study of economic conditions in the Bombay Presidency, shows that the economic effect of prices differs in different classes of the agricultural community, and it is well known that dry years are, on the whole, the healthiest, though they are not usually years of economic prosperity. On the one hand there appears to be an intimate connexion between the quantity and distribution of the rainfall and the intensity of the infection of the diseases, such as malaria, dysentery and so forth, which are chiefly responsible for the mortality, while on the other hand there is always in an agricultural population, even among those near the subsistence limit, a considerable margin of resource, which enables them to resist in a remarkable way temporary economic stringency.

3. The annual fluctuations of the birth and death rates are, therefore, probably much more dependent on the intensity and onslaught of the principal diseases, than on any supposed variations in the resisting power to them of the people, owing to economic circumstances. In a graph showing the death rates over a long period of years a mean line drawn through the fluctuations would indicate the cultural and material progress of the population and its surroundings, while the annual fluctuations from the mean would show usually the result of temporary climatic and environmental changes and only occasionally economic catastrophies. The undoubted development of material resources

has not, in the ordinary agricultural community, been accompanied by a cultural advance such as would affect the population quantitatively. To put the argument as simply as possible, if you could double or treble the annual income of every family in the poorer portions of the population, the effect on the vital statistics would not be noticeable for several decades, while if you could ensure each household against the economic effect of the ordinary fluctuations of the harvests it would not affect the annual variations in the birth and death rates. The chief factors are cultural, climate and environmental rather than directly economic.

Over Population.

4. But by whatever means the natural growth of the population of India is controlled, the actual increment in the last 50 years is considerable, amounting to well over 50 million persons; and a normal increment of 8 per cent. unchecked by any serious catastrophy would represent an addition in the next decade of over 25 millions. The question is being seriously asked by many thoughtful writers whether we are faced by " over-population," *i.e.*, by a dangerous pressure of population on the means of subsistence. In tracts, such as parts of the Gangetic Valley and of the eastern portions of Bengal, where the density of the population reaches 1000 and even 1200 persons per square mile, one would suspect that such pressure would be most acute. But economic pressure may exist at any degree of density. It is responsible to a large extent for the unrest in the tribal areas of the N.-W. Frontier, where the average density is at a ridiculously low figure; and Dr. Mann has shown, in his discussion of the conditions of typical villages in the Bombay Presidency, that pressure exists in tracts where the actual density is not much above the average. In India, where the population is predominantly agricultural, the economic aspect of density resolves itself into the question of the relation between the population and the productivity of the land. The capacity of the land again depends, apart from its extent, on its scientific treatment and economic organisation; and agricultural methods, choice of crops, distribution of holdings, systems of tenures, development of markets and of communications are all factors in the expansion of the potential resources of the land. Mr. Calvert, in his book already quoted, shows that there exists in the Punjab, which is mainly an agricultural tract, apart from the extension of irrigation, an enormous margin for the development of agricultural wealth. In India as a whole, with its waste places and its industrial and mineral potentialities, local " over population," due to the overtaking of the existing material resources of a tract by the expansion of the population, is a matter of temporary want of adjustment; and in the historical life of a nation the temporary hardships and difficulties involved are probably more than counterbalanced by the stimulus to enterprise and progress which this lack of adjustment brings.

MIGRATION.

5. Meanwhile the birthplace statistics of the census give a valuable indication as to the manner in which local pressure of population is being relieved by redistribution. The completion of the great irrigation works of the Jhelum and Chenab Rivers has thrown open in the last 10 years large areas of land in Northern India for cultivation. There has been an important movement of surplus population from the congested tracts of the centre and north of the Punjab into the canal areas of the south-west of the Province. In the east of India the undeveloped lands of Assam have attracted thousands of permanent agricultural colonists from the dense areas of Eastern Bengal, while the tea garden population is steadily drawn from the lower strata of the United Provinces, Central Provinces and Bihar and Orissa. Assam has almost doubled her population in the last 50 years and it has been calculated that nearly a quarter of her present population is of foreign extraction. In the same way the waste lands of Orissa and the Santal Parganas are attracting increasing numbers of colonists from the neighbouring areas, especially the congested areas of the Ganges Valley in the United Provinces. But apart from the movements of agricultural colonists there are important streams of labour migration partly for agricultural and partly for industrial purposes. Bihar and the western portions of the Central Provinces pour out their labouring population eastward to gather the harvests of Bengal and to fill the coal mines, jute factories and docks of the eastern industrial areas. The United Provinces sends three quarters of a million labourers to Bengal, Bombay, the Central Provinces, Assam and Burma. The enormous reservoir of labour filled by the backward classes of the Madras Presidency overflows into the plantations of Mysore and Travancore and supplies the larger part of the overseas stream to the plantations and factories of Ceylon, the Malay States and Burma. Burma has now more than half a million Indians, two-thirds of whom are Hindus or aboriginals. The majority are labourers from Madras, Bengal, and the United Provinces, and the increase in the decade is about 16 per cent. Labour emigration out of India has recently been checked by legislation but there are nearly 1¾ millions of Indians in other parts of the British Empire, most of whom are labourers. While a considerable part of the movement of labour in India is periodic and temporary, the labourers leaving their families behind and returning to their homes after the harvests or at periodic intervals, there is undoubtedly an increasing tendency towards permanent movement and settlement, and in many cases the migration which is here described, and which the improvement of communications has done much to stimulate, is an important factor both in the material improvement of the resources of the people, and as a moral stimulus which is gradually overcoming the conservative and immobile character of the population.

URBAN CONCENTRATION.

6. Another aspect of the redistribution of the population which has in India some interesting and characteristic features is the distribution between country

and town. The Indian is not, as a rule, a genuine town-dweller and urbanisation has made very slow progress, the whole increase in the urban population in the last thirty years amounting to only one per cent. Even this increase is confined within very limited areas. Many of the areas classed as towns have few genuine urban characteristics, a considerable portion of their population being actually or virtually agricultural. The figures show very clearly that the medium-sized country town is either stationary or decadent and that it is only, or at any rate chiefly, in the large towns and cities that, under the influence of commercial or industrial expansion, there has been any considerable growth of population. In these larger classes of towns, viz.: towns of over 50,000 persons, the increase in the urban population amounts to 16 per cent. or more in the decade; in towns between 20,000 and 50,000, 8 per cent., and in towns between 10,000 and 20,000 less than 1 per cent. A somewhat ominous feature in connexion with this urban industrialisation is disclosed by the sex statistics of the larger industrial towns. While, for example, in Bengal the proportion of women to men in all towns has been steadily falling, showing that a growing proportion of the town populations consists of more or less temporary immigrants who have left their families behind, this growing disparity in the sex ratio is specially conspicuous in Calcutta and the industrial towns, and is becoming a real danger signal. The influx into the industrial areas of male labourers who have left their families behind has steadily increased, so that in Calcutta males outnumber females by over two to one; and the corresponding change in the average sized industrial or commercial town is still more remarkable. In Calcutta, where there are only 374 married women per 1000 married men and only 47 per cent. of the women were returned as married, the predominance of males must involve a great increase of sexual irregularity. The male labourers being nearly all married with a wife somewhere away at home in the country, this disparity means that most of the workers are leading an unnatural existence, missing the steadying influence of home life, and only anxious to earn enough to get back to their homes and families. It is not unnatural that their employers find that they have little heart in their work and that they are notoriously unsteady. Similar conditions obtain in other large industrial centres. The cosmopolitan population of Rangoon has a sex-ratio of 444 women per 1000 men, which contrasts conspicuously with that of the resident Burmese city of Mandalay, where there are as many as 915 women to every 1000 men. Though the industrial areas of the Bombay Presidency have a large foreign population, immigrant labour is of a more permanent nature than in similar tracts in the east of India, and there is more employment for women in the cotton mills than in the mines and factories. Bombay itself has 524 women per 1000 men and the ratio in Karachi is 629, in Ahmedabad 763, and in Sholapur 894, all of these towns except the last having cantonments within their areas. These figures suggest an evil connected with the growing industrialisation of part of the Indian population which is, however, largely due to the fact that at the present stage of industrial progress there has not yet been established a definite industrial labour population. The labour which the industries employ is still chiefly drawn from the agricultural population which has its heart and its home in the country.

COMMUNAL DIVISIONS.

7. There are various ways in which it is possible to classify the population for demographic purposes, *e.g.*, religion, race, birth-place or social or economic condition. In a Census Report attempt is made to distinguish these different systems of classification, but I propose here to mention briefly some groups which, whether on account of religion, race, social or economic reasons, seem to be marked off from one another by differences of culture, tradition or point of view, and have a communal individuality.

HINDUS.

8. Hindus now number 216 millions, or over ⅔rds of the total population. But in marking off the Hindu community we are always faced with the difficulties (1) of the large body represented by the lower strata, whose beliefs are largely animistic and whose connexion with Hinduism is of a somewhat slender nature, and (2) of a smaller number, belonging mostly to the hills and forests, who return themselves, or are returned, as adherents of tribal religions, such as Gond, Oraon and so forth. The former class, who include the large body of "untouchables" amounting to between 50 and 60 millions, are for census purposes included among Brahmanic Hindus. The recorded followers of the tribal religions number nine and three quarter millions, but the border line between these tribal religions and the Hinduism of the lower classes of Hindus is vague, and the record in the case of the tribes is so arbitrary, depending largely on the whim of the enumerator, that it is doubtful if the figures have any great statistical value. Taking the figures for Hindus, however, as they are recorded, there has been a steady decline in their proportion since the Census of 1881. The fall is marked in Bengal where the proportion of Hindus dropped from 45 to 44 per cent., while the Muhammadans rose from 52 to 54 per cent. While the Hindus gain by the absorption of the tribal communities they lose by transfer, chiefly from their lower ranks, to Christians and Sikhs and to the Arya Samaj. It is, again, in the tracts in which Hindus predominate, in Bombay, the United Provinces and the Central areas of the country, that the highest mortality occurred. The caste statistics are not sufficiently accurate to enable us to separate off the various strata of Hindu society, but the trend of political and social thought suggests three main divisions of which some numerical estimate can be given. We can place the Brahman community fairly accurately at about 14 million. The "depressed" classes of untouchables, including recently Hinduised tribes, number about 60 millions giving as a remainder of 143 millions representing the non-Brahman Hindu castes, which

include the chief agricultural and higher artisan communities as well as the fairly large body of professional men and traders.

CASTE.

9. I do not propose in this paper to say much on the subject of the castes or races of the people, as the scientific aspect of caste has been fully discussed in the caste chapters of previous census reports, and ethnography has not formed an important part of the investigations at the recent enumeration. The census staff is, however, brought into close contact with the practical features of caste, and it may be of interest to recall some of the impressions regarding present day tendencies of caste which the process and the records suggested. We found in our operations strong evidence of increasing caste consciousness accompanied by intense caste patriotism, caste jealousy and even caste antagonism. There is no part of the census operations which excites more interest among the enumerators and the general public than the entry of caste and at the decennial enumeration occasion is always taken by the leaders of a caste or sub-caste to press for recognition of social claims. Communal organisation has extended and intensified during the decade partly under the influence of political rivalry and partly as the result of educational and economic progress, and all the principal castes now have their caste " sabhas " or associations, formed for the purpose of representing and forwarding the rights and claims of the caste. With most of these caste sabhas the census came in touch in one way or another, through petitions and personal interviews with the caste representatives, and a good deal of ingenuity and tact was necessary in order to deal in a reasonable way with the pretensions put forward, without hurting the feelings of those interested. Now there is no doubt that the effect of this intensification of communal feeling is to preserve and increase the forces of orthodoxy and tradition. The ambition of each caste is to move upward in the social scale and to do this it must cling to the strictest traditions of Hinduism. But as it must also close its ranks rigidly to the pretensions of those below it the result is to make any movement more difficult for everybody. Wealth and culture may occasionally enable individuals to rise, but the structure of society remains unaffected, and there is certainly in the general community no evidence of the loosening of the essential bonds which bind an individual caste together and differentiate it from the others. There are, of course, exceptions to this generalisation. In the case of Hindus, who for any cause are permanently expatriated from their own homes, and in the case of small communities of Hindus living practically isolated among a people of different traditions there is a distinct tendency towards the relaxation of caste restrictions especially among those of lower castes. The Hindus who leave India and make their home in the colonies or Burma are mostly drawn from the lowest castes of South India and are only too glad to forget their origin and caste traditions in the home of their adoption. In

the North-West Frontier Province, where a small number of Hindus and Sikhs are surrounded by a large Muhammadan population, caste restrictions, already lax, have considerably weakened during the decade. A large proportion of them observe no restrictions of interdining and there is a strong tendency to widen the endogamous groups and narrow down the exogamous circle. Again the influence of the Arya Samaj in North India is in favour of a gradual loosening of caste orthodoxy, while a great many among the educated professional classes of the large cities, who have been brought in touch with Western civilisation, will willingly abandon orthodoxy to the full extent permitted to them by their social environment.

MUHAMMADANS.

10. The Muhammadans, though they have no racial uniformity,—for it has been estimated that even in the Punjab only about 15 per cent. are of genuine foreign extraction—are by virtue of the distinctive characteristics of their religion and culture a more homogeneous community than the Hindus. They now number in India 69 million persons, of whom all belong to the Sunni section except a small minority, forming about three per cent., who chiefly consist of the Borahs and Khojas of Western India and some of the Mappilas of Southern India. Islam has drawn into its fold members of practically all the races of India, and the community includes more than half of the cultivating classes of Bengal, who live side by side with their Hindu neighbours of the same race and origin and with the same essentially primitive outlook and superstitions. In spite of this racial medley there persists throughout the various peoples who hold the creed of Islam a strong feeling of communal unity, which political development in India has of late years done much to foster.

SIKHS.

But it is among the smaller communities that the more interesting effects of communal feeling have reacted on the census figures. The rapid increase in the Sikh community in the last thirty years is specially important. In 1891 the Sikhs were returned as under two million persons; the census of 1921 shows them as nearly three and a quarter millions. All but 4 per cent. were enumerated in the Punjab and its States, where they form about 12½ per cent. of the population. The reason of this rapid growth of Sikhism undoubtedly lies in the revival among them of a strong communal feeling, and the conversion to Sikhism of many of the depressed classes who formerly swelled the ranks of Hindus.

ARYA SAMAJ.

11. Another small community of considerable interest is the Arya Samaj which now counts 468 thousand followers in India. The community has almost doubled its numbers since 1911, its efforts at proselytism being specially successful among the lower classes of Hindus to whom it offers a means of

raising their status by freeing themselves from the shackles of caste. In this respect the Arya Samaj is a distinct rival of Christianity, which makes its appeal largely to the same class of the community. But while the Arya Samaj appeals rather to those who have some material standing and desire to rise in their own community, the Christian missions have more success with those who, having no material prospects, see nothing to hope from Hinduism and are ready to break with it altogether.

CHRISTIANS.

12. The Christian community now numbers just four and three quarter millions of people in India or 1½ per cent. of the population. More than half the number are returned from the Madras Presidency and its States. There are now two and a half times as many Christians in India as there were in 1881, forty years ago. While there has been a steady growth in the churches of South India, a more interesting phenomenon perhaps is the mass conversion in Assam and Bihar and Orissa. In the Khasi and Jaintia Hills a sixth, and in the Lushai Hills over a quarter of the population are now Christians. In the former tract the increase is about 32 per cent. in the decade, but in the Lushai Hills the spread of Christianity has been phenomenal. In a district of 7,000 square miles, sparsely populated by less than 100,000 persons, there are now more than 27,000 Christians where ten years ago there were only 2,000. Similar mass movements have taken place in Bihar and Orissa among the Oraons, Mundas and Kharias. The opening up of Chota Nagpur and the neighbouring country in the Central Provinces has brought the tribes in touch with a higher standard of life. The effect during the decade was seen partially in a revival of tribal communism among the Oraons and later among some of the other tribes, which took the form at first of a strong resentment towards foreigners of all descriptions and gave considerable political trouble at one time. The tribes have settled down again to a peaceful existence, but how far this growing feeling of tribal self-consciousness will affect the spread of Christianity is an interesting question. There are two new forces which Christian missions will have to recognise, the progressive organisation, both social and political, of the classes in the lower grades of Indian society, and the growing interest which is being taken in the depressed classes by the leaders of thought in the higher ranks of Hinduism. The proselytising efforts of the Arya Samaj are having a distinct influence in North India, but the depressed class missions started by more orthodox Hindu societies in the south and west of the country have not yet reached a stage in which they seriously affect Christian missionary enterprise.

13. There are two small communities which can be distinguished from Indians proper, both by virtue of racial origin, and to a certain extent of an individuality of interest and outlook, namely the Anglo-Indian domiciled community, numbering 113 thousand, and the Parsis, of whom 102 thousand were enumerated. Both these communities, though small, are an important

part of the population and have their own interests and problems. The Parsis, who are, of course, chiefly inhabitants of the Bombay Presidency, though their interests and outlook are now Indian, have preserved their racial and cultural traditions. But perhaps owing to the fact that their economic condition approaches more nearly to Western than to Asiatic standards, they are already subject to the reduction of birth rate, which seems inevitably associated with high cultural conditions, and unless they can keep their death rate correspondingly low are faced with the prospect of an arrest of growth and eventually a decline in numbers.

OCCUPATIONAL CENSUS.

15. In point of view of interest and importance the statistics of occupation are the most valuable of all those obtained at a periodical census. At the same time they are undoubtedly the most difficult to collect with accuracy and compile with precision. In the first place we must decide whether we desire to know the means of subsistence of the whole population or the occupation of workers only or both. If we wish to record occupation as well as means of subsistence, as has been done since 1901 in India, it is necessary to distinguish between workers and dependants, and here we are faced with the first difficulty, since a large part of the population, including many women and children, contribute by work something to the resources of a household without necessarily being full-time workers. Again a man may have several occupations all of which are remunerative. He should obviously be entered under the category which includes his primary or most remunerative occupation, but it is not always easy to say which this is, especially in such cases as agricultural labour combined with weaving, or fishing with boating and so forth, which form the dual occupations of so large a part of the lower classes. The distinctions between worker and dependant, and between dual occupations, involve subtleties of interpretation which continually give trouble in individual cases, and the extent to which the occupations of women and children actually contribute to the income of a family must always be a matter of opinion and give rise to inconsistencies in the returns. Having obtained our statistics it is necessary to classify them under appropriate categories. Experience shows that the Indian statistics are not sufficiently accurate to admit of an extremely detailed classification. The scheme used at the present census is the same, with some small modifications, as that introduced in 1911 by Sir Edward Gait, and is founded on a classification scheme devised by Bertillon, which has been adopted in a modified form for the census of England and of some of the dominions. It must, however, be remembered that the occupational statistics collected in the census give at best only a general sketch of the functional distribution of the people, and are too vague and imperfect to afford any detailed comparison in most of the smaller categories with statistics of the past or figures of other countries.

FUNCTIONAL DISTRIBUTION.

16. India is essentially an agricultural country and agriculture proper supports 224 millions of persons or 71 per cent. of the population of the Empire. If we add the pastoral and hunting occupations the percentage is 73. Industries support 10 per cent. of the population, but the bulk of these are unorganised industries connected with the supply of personal and household necessities and the simple implements of work. Organised industries occupy only 1 per cent. of the people. In trade and transport, on which less than 6 per cent. and 2 per cent. respectively, depend, a not inconsiderable number are connected with the disposal of the various kinds of agricultural products. The administration and protection of the country engages less than 5 millions or 1½ per cent. of the population and the remainder are supported by domestic and miscellaneous occupations. Though the extent to which agriculture predominates varies in different provinces, there is no region in which it does not in some form easily take first place. Of industrial workers the largest proportions in the local populations are in the Punjab, the United Provinces and in Bombay. The industrial occupations are, of course, in India mostly of the cottage industry type. In Bombay the development of organised industries is of considerable importance, but it is largely confined to a few of the biggest cities. Compared with 1911 agriculturists have increased a little faster than the total population; so also has trade, especially trade in textiles. Industries, however, have substantially decreased, the textile workers having dropped considerably. As has already been said, however, too much emphasis must not be laid on these comparisons. The huge amorphous category of " labour," which fluctuates between agricultural and industrial employment and is capable of being recorded equally under either group, is almost sufficient to turn the scale, where the general increase in the population has been so small as in the present decade. But there seems to have been a real increase in the number of cultivators in the United Provinces at the expense of labour, and the rise in the Punjab is undoubtedly due to the extension of the canal irrigation areas.

AGRICULTURE.

17. The term " agricultural occupation " includes the owners of land who receive rent from the land, the actual cultivators of the land, and the farm and field labourers. We distinguish the figures under these various categories, and some interesting comparisons can be made between these figures themselves and between them and figures obtainable from other official records. For example we can illustrate the varying size of landed property in Bengal by calculating that the number of cultivators per 100 landlords varies from over 17,000 in the Chittagong Hills to 750 in Howrah. Or an even more interesting comparison can be made between the number of cultivators (workers) and the acreage cultivated. The figures for some of the main provinces show variations between 1215 acres per 100 cultivators in Bombay to 251 acres in the United Provinces.

India is a country of comparatively small holdings, often of the allotment size, but cultivated on an extensive system applicable to large areas and under a method which, as it utilises to the full neither the energy of the worker nor the productivity of the soil, is the reverse of economic. In the British Territory of Bengal there is an average of 2¼ acres to each agricultural worker including cultivator and labourer. It is in such figures that the explanation of the poverty of the cultivator lies. The cultivation of such a plot cannot employ a man for more than a comparatively small number of days in the year, and even in the Punjab Mr. Calvert estimates that the work done by the ordinary cultivator does not represent more than 150 days of full labour in 12 months, and that even in the occupied days the idea of the Indian cultivator of what constitutes a full day's task is well below that prevalent in more progressive countries. If Mr. Gandhi could find to occupy the leisure of the cultivator something which is not quite so economically hopeless as yarn-spinning he would confer a real boon on the Indian peasant. Another interesting comparison could be made between the number of field labourers and the number of cultivators. For example, in Bengal the number of field and farm labourers works out to an average of one labourer to every 5 cultivators and in Eastern Bengal to as few as one labourer to 8 cultivators. We may contrast the conditions in England and Wales, where, according to the census of 1911, there were over 3 hired labourers to each farmer and in 1851 before the spread of machinery there were in England about 6 labourers to each farmer. In the United Provinces the proportion is approximately one labourer to every six cultivators. These figures again illustrate the fact that the average holding is usually so small that the cultivation of it is not too much for the owner of it himself to accomplish.

PLANTATIONS.

18. Under agriculture is included also the plantations of special products such as tea, coffee, rubber, indigo and so forth, for which we also have figures collected on special industrial schedules. According to this census these plantations employ 820,000 persons. The tea garden population of Assam, which is drawn largely from the labour reserves of the United Provinces, Central Provinces and Bihar and Orissa, has increased in the decade by 35 per cent. according to the figures, the actual increase being probably larger. The number of gardens has risen from 609 to 795. The tendency at the present time is for the gardens to pass out of the hands of private European and Indian owners, and for companies with Indian directors to take a much larger share than formerly. The spread of the tea industry into the Eastern Hill tracts of Bengal has been entirely due to Indian enterprise. We may notice the large proportion of women who find work in these tea gardens. In Assam the number of females per thousand male workers in the gardens is 910 and in Bengal 1157. These proportions contrast favourably with the sex disparity already alluded to in the industrial areas of the eastern provinces. There is work also for the children

who number about 20 per 100 adults in the lists of workers on the plantations, so that the migration of labour from Central India to these plantations is the migration of families and not of individuals and forms a much more healthy outlet than the concentration into the industrial areas.

INDUSTRIES.

19. It has for various reasons been impossible to hold in India a census of production such as regularly carried out in England, but in order to place at the disposal of the administration and of students more detailed statistics regarding the ownership, management and personnel of the organised industries of India, Sir Edward Gait brought into effect in 1911 a special schedule to be filled up by the managers of all industrial undertakings employing 20 or more persons. This special census was extended in 1921 to include undertakings employing 10 or more persons and I enlarged this schedule, splitting it into two parts, one to cover owners, managers, clerical staff and power used, and the other for operatives skilled and unskilled. Besides the industrial enterprises proper this special census was taken in the plantations of tea, coffee, indigo, &c., and in the mines. The total number of all kinds of establishments thus enumerated comes to 15,606, employing 2,681,000, of whom 123 thousand belong to the directing, supervising and clerical establishment, 724 thousand are skilled workmen, and 1,829,000 are unskilled labourers. European companies own the majority of the tea gardens of Assam and Bengal, but, as has already been seen, Indian enterprise is growing in regard to private ventures. Indigo in Bihar and Orissa, coffee in Madras and rubber in Travancore are mostly in European hands, but the coffee plantations of Mysore are largely owned by Indians. Most of the large collieries are held by European companies, as also the oil-fields of Burma. The cotton industry of Western India is almost entirely Indian, while the jute mills of Bengal are in European hands though the smaller presses are mostly owned by Indians. The rice and flour mills and the brick and tile factories, with the exception of a few large concerns, are in the hands of Indians. Of the total number of persons employed in these organised industries 28 per cent. were on plantations, 16 per cent. engaged in the cotton industry, 12 per cent. in jute and 8 per cent. in coal mining.

COLLIERIES.

20. The most important coal mines lie in the provinces of Bihar and Orissa and Bengal. The Jherria coal-field of Manbhum itself produces over half of the total coal output in India. There are now 581 collieries as compared with 353 in 1911, and the persons employed have increased from 143 to 181 thousand. The labour is not so systematically recruited as it is for the tea gardens and is usually obtained through contractors. For many miles round the coal-fields many of the villages follow a dual occupation, working in the fields in the season of planting and harvesting, and cutting coal for the rest of the time. There is

as yet no sign of a professional mining population and probably less than 20 per cent. of the workers are "settled" in the sense that they are permanently resident in the coal-fields.

JUTE.

21. The labour population in the textile industries is much more settled. The jute industry of Bengal supports nearly half a million persons, according to the general census, and actually employs about 310 thousand of these, including 52 thousand women and 23 thousand children. The industry is practically confined to the banks of the Hooghly and measured by the number of employés has grown by 42 per cent. during 10 years. The jute industry is almost entirely controlled by Europeans and the Bengal mills employ in the supervising and clerical staff over 900 Europeans and Anglo-Indians. About ¾ of the working population comes from outside Bengal, but it is well housed and a good proportion are permanent employés.

COTTON.

22. Unlike the jute industry of Bengal, the cotton mills of the west of India are almost entirely in the hands of Indians, the number of European textile companies in Bombay being only 17 out of 193. There has been considerable progress in the cotton industry during the decade, the Bombay figures showing an increase in textile establishments from 497 to 566, and in the number of operators from 198 to 278 thousand persons. The cotton mills provide permanent employment to a more or less settled population and the problems of labour are somewhat different to those of Eastern India. They are the problems of large cities with a growing proletariat, which has to be properly housed, educated and maintained under decent sanitary conditions.

23. The progress of industrialisation in India and the problems connected with industrial labour form a subject of which the census can only touch a fringe. I have mentioned a few of the difficulties which the census figures disclose and illustrate. Our attempts at an industrial census are necessarily imperfect and limited, but it is to be hoped that they will lead to a properly organised census of production, which will put at the disposal of students and the administration the statistical information necessary for the solution of these problems.

DISCUSSION.

THE CHAIRMAN said that all would agree that the author had dealt in a very interesting way with a number of important problems connected with the Indian census. On most points he (Sir Edward Gait) found himself in general agreement with Mr. Marten's conclusions, and even where this was not altogether the case, the apparent difference was probably due largely to the fact that where so much ground was covered the necessity for rigid compression led to the omission of the requisite qualifications to broad generalisations. For instance, when Mr. Marten estimated at 8 per cent. the normal decennial growth of the population of India due to excess of births over deaths, it was evident that he did not mean that this was the rate of growth which ought to be expected ; for the average decennial increase in the five periods for which statistics were available was only half this figure. On three occasions the increase was 1½ per cent. or less ; once it was 9½ per cent., and once it was 6½ per cent. What the author meant was that 8 per cent. was the rate to be expected in a decade free from widespread and severe famine and also from exceptional unhealthiness. But even so, the statement required some qualification, for the rate of growth in any given period was largely dependent on the age distribution of the population, and this varied greatly from time to time. For instance, in a severe famine the mortality resulting from insufficient and unwholesome food occurred mainly amongst the very young and the very old, many of whom, in the ordinary course of events, would have died a few years later. People in the prime of life were but little affected. Consequently the period after a famine was usually one of exceptionally rapid growth, a high birth rate being accompanied by a low death rate due to the premature disappearance of many of the bad lives. The change in the age constitution of the population resulting from the great South India famine of 1877 was thus an important factor in the growth of 9½ per cent. which took place in the years 1881-91. The famines of 1897 and 1900 had a similar effect on the age constitution of the population, and the growth in the period 1901-11 would probably have been equally great but for the appearance of a new disturbing factor, plague.

The terrible influenza epidemics of 1918-19, which swept away 12½ million of the population, had an equally disturbing effect on the age constitution, but in the opposite direction. This disease was especially fatal to people in the prime of life, so that at the commencement of the current decade there was an unusually low proportion of married women at reproductive ages. Consequently, even if there was no unusual mortality meanwhile, he ventured to doubt whether the census of 1931 would show a growth equal to the author's " normal " figure.

There could be little doubt, however, as to the correctness of the author's conclusion that, apart from exceptionally severe and widespread famine, the periodic variations in the rate at which the population of India grew depended more on conditions directly affecting the health of the people than on the degree of agricultural prosperity. The tendency to lay undue stress on agricultural conditions, from which he (the Chairman) confessed that he had not been altogether free himself, was a survival from the time when the staying power of the people was far less than it was in the present economic state of India, and when the arrangements for combating famine by prompt and effective relief measures were far less perfect than they now were.

They had been told that " in India as in every other country the most prolific portion of the population is at its lowest stratum." This was undoubtedly the case in our own country, where the reasons for it were well known. Owing to prudential considerations the better classes married much later than the lower, and they more often refrained from having more children than they could afford to bring up properly. But in India, save amongst a numerically insignificant section, practically every girl, of all classes, high and low alike, was married by the time she was capable of having children, and there was no such thing as birth control. The lowest stratum might have a slightly higher birth rate, but he would be inclined to think that this was to a great extent neutralised by a higher infantile mortality. The statistics as to the size of families which were collected in connexion with the last census were tabulated by social classes in two areas only, and in these the results seemed to him somewhat inconclusive, though they certainly showed that Brahmans had relatively small families.

In dealing with the question of over-population, the author had pointed out that in an agricultural country like India the productivity of the land was the prominent factor, and had said that there was less congestion in many fertile tracts with a high density than in some barren tracts where the population was very sparse. The sea-coast division of Travancore afforded a striking instance of a densely inhabited agricultural tract which was still growing very rapidly. Although it now had a density of 1,266 persons to the square mile, its population had been growing during the last 30 years at the extraordinarily high rate of 15 per cent. per decade. On the other hand, South Bihar, with 502 persons to the square mile, had a smaller population now than it had 40 years ago.

He had not left himself time to discuss the subject of occupations, but he wished just to draw attention to one point. The census statistics showed the functional distribution of the people on the particular day (in the spring) when the census was taken. Had it been taken at some other season, say during the main harvest, some of the results would have been very different—for instance, the proportion of labourers to cultivators in Bengal would have been far higher than that mentioned in the paper.

Mr. A. Yusuf Ali, C.B.E., late Indian C.S., said he had seen a gradual change in the point of view of the Indian census. The earlier censuses were mainly ethnological. It was desired in them to find out what the racial basis of the population was, and the data which were furnished by the early workers were, he thought, as far as the people's traditions were concerned, almost the final data ever to be got on the ethnological side. Later the census devoted the main part of its attention to sociology—caste and questions of that kind, and on that point he did not think the census had had its final word. The Chairman, in his report on the census of which he was Commissioner, had given most valuable deductions on that subject, and he (the speaker) viewed it with a certain amount of disappointment that the later censuses appeared to have considered that chapter of the inquiry almost closed. It seemed to him that caste was not stationary. It had undergone a very great transformation within one's own life and experience, and it would probably undergo many more transformations in the immediate future. Even where there was a tendency for the growth of caste consciousness or caste organisation, there was at the same time, even in the same caste, a tendency to relax the old rules and to consider the caste organisation on an entirely different basis. Take for instance the Kayasths. It would be wrong to call them any longer the writer caste. Members of this class were spreading themselves through the entire field of literary and professional occupation, and there were now probably quite as many lawyers as writers in the caste. It would be well to devote to the sociological field a little more intensive study and to bring out the dynamic movements that were transforming the whole face of Indian society. But the chief interest now seemed to be economic or industrial. The paper had given a very clear reason why the census of production was very difficult to carry out in connexion with the actual census of population; but there was the example of the penultimate census and of the last census to show how the ordinary population census could be made to subserve the purpose of an economic or industrial census. He hoped that the special tables which were to be compiled would be extended and that a rather more penetrating inquiry would be made into the actual production of the country. They all knew that at the present moment in India, in the Assembly, various suggestions, wise and foolish, were being made for estimating the income of the people. It was an economic question, and one would think that ordinarily it would be the last to stir up people's passions. Yet it seemed remarkable that people should at the present moment go back to the absurd figure of 23 or 27 rupees as the average yearly income of the people in India. He did not think that anybody who had lived, if only for a year in India, could question that, even in the lowest grades of labour, 27 rupees a year could not represent the income of a person, much less the average income of the whole country. It was of some importance that both the Government and the people should know how the average income of the people had moved. He did not think that in this matter either the Government or the people had anything to be ashamed of. It was perfectly clear that the economic standards of India were rising, and perhaps they had risen more among the lower classes and the working population than the middle classes. The middle classes did not seem to have adapted themselves quite to the great social, economical, and political revolution which had taken place in India, and the problem of the future would be clearly to distinguish between the labouring classes of the country and of the towns, and in the middle classes, those who had to work in the management and control of industrial occupations and those who represented the professions. Economically an inquiry of that kind would lead to very valuable results, and might be helpful in the laying down of a strong and useful industrial policy in India. The question of a C3 versus an A1 population was never more urgent than in the India of to-day.

Sir A. Baines, C.S.I., said that as a former labourer in the same vineyard he welcomed the chance of congratulating his successor upon the excellent crop he had got from it, under more intense cultivation than it received in earlier years. Time would only allow of reference to one main point in the problems discussed, viz., the connexion Mr. Marten had indicated between the population question and the social system in India. During the last 30 years or so the most influential factor in the rate of growth had been the incidental virulence of the "positive checks," in the form of epidemics and famine; the long-distance curve, therefore, was far from indicating anything approaching a normal rate, but it sufficed to exhibit the deplorable expense of life by which, irrespective of epidemics, even a moderate natural increase was maintained. The reduction of this waste, as had been pointed out in the paper, could only be effected by far-reaching change in the social organisation, and this practically meant reform from within of the caste system, the basis of Indian social stability. This system had resisted external influence for thousands of years, and, in spite of recent changes already mentioned, it remained, in all chief attributes, substantially as it was. Point was thus lent to the need for continuous and careful watch over the chronicle and local statistics of caste, by both administrators and anthropological experts. Caste entered, again, into the suggestion that the very irregular distribution of the population might be to some extent equalised by migration from the densely-peopled tracts to the vast area still sparsely inhabited. Apart from the question of the distinction between economic density and that merely numerical, the uprooting of castes was far more difficult than even the change of language and climate, so that permanent migration on a large scale was only easy where, as in the Punjab, the movement consisted chiefly in no more than the expansion over the periphery of a circle. He must stop here, only expressing the gratification with which he had listened to a thoughtful exposition of some most difficult problems.

Sir Louis W. Dane, G.C.I.E., C.S.I., said that the Chairman had pointed out how extraordinarily difficult and indeed, almost impossible, it was to lay down any general rate of increase in the population of India from one census to another. In the last census it was more than ordinarily difficult. In the Punjab, two years before the census was taken, the Province was swept by influenza which was similar to pneumonic plague. More than 10 per cent. of the population died in a year, and, unfortunately, the 10 per cent. that died were taken from what might be called the younger middle-aged class. If it had not been for that extraordinary wave of disease, he thought that instead of no increase there would have been an increase of 12 per cent. at least in the Punjab. One point mentioned in the paper was the extraordinary increase in the number of Sikhs between the census of 1901 and that of 1921. The author had correctly put it down to the revival among the Sikhs of the strong communal feeling now springing up in India. But there was another reason. There were two classes of Sikhs. It would be remembered that there were ten spiritual leaders of the Sikhs, and the first nine of these, headed by Guru Nanak, were not Sikhs in the sense in which people commonly used that term. They shaved and smoked, and behaved in all other ways practically as Hindus. It was only when the tenth guru, Govind Singh, introduced his special code of laws that the communities of Singhs came into existence. Most persons were accustomed to think of the Sikh as a Singh, one who wore long hair and did not smoke. Up to the 1911 census there was a great tendency for all the Nanakpanti Sikhs or followers of Guru Nanak and the first nine gurus to regard themselves as Hindus. The idea that they should show themselves as Sikhs sprang up about 1910 or 1911, and a good deal of the increase shown in the last census was probably due to there being now an accurate return of the two classes of Sikhs in the Punjab. This fact also explained a good deal of the trouble which had been agitating the Punjab in connexion with the maintenance of the shrines of the gurus. As the first nine gurus were practically Hindus, naturally the custodians of the shrines were Hindus, but that was not considered desirable by others of the Sikh community. He thought it well to explain that even in the census these difficulties of religion occurred.

The lecturer had pointed out that if due allowance were made for the differences in standards of requirements and necessities the Indian cultivator was not as badly off as was generally thought. He entirely agreed and believed that in some provinces he was as well off as the same class in Europe.

One of the previous speakers in the discussion cast considerable doubt on the figure of 27 rupees a year as the average income of an Indian. His own experience was that these generalisations were absolutely futile. He had constantly found that people dealing with land-revenue settlements would make out the most convincing figures, but the extraordinary anomaly would be discovered that a district which was supposed not to produce enough grain to feed its population had in fact, as shown from the railway returns, exported large quantities. He was almost disposed to say that it was false to allege that India was a poor country at all. It was not a poor country, at any rate, so far as large tracts of it were concerned. He himself was one of the first to draw attention to the fact that certainly in Northern India the amount of money that was being steadily imported into the country was absolutely phenomenal. Between 1909 and 1913 something like four million sovereigns a year were imported into the Punjab. At that time the Punjab would not have anything to do with notes. The people were accustomed to bury their money in the earth, and when they did so they found that notes so buried were often destroyed. During the war there was a great boom in note circulation, as the great earnings could not be converted in any other way, but now the people had gone back again to the same desire for gold. For the last six months that supposedly poor country, India, had practically been taking between three-fourths and four-fifths of the whole available gold of the world. He thought that the inquiry* into the economic situation which had been suggested in that discussion would be very desirable, and he would be very much surprised if, as a consequence of such inquiry, a great many ideas as to the real poverty of India were not dissipated. He concluded by moving a vote of thanks to Mr. Marten for having written a most instructive and learned paper and to Mr. Crosthwaite for reading it to the meeting.

The motion was carried unanimously.

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*Note.—Since the lecture the appointment of a small committee of three, to make a preliminary economic survey of the condition of India has been announced. One of the three is Pandit Hari Kishan Kaul, probably the first provincial Census Commissioner not a member of the I.C.S. He carried out the Punjab Census of 1911, and his appointment, though regarded as a rash experiment at the time, has been triumphantly vindicated.—L.D.

CORRESPONDENCE.

"RAYON."

It was with a great deal of interest that we read your article on the Artificial Silk Industry in France, which appeared on pages 161 and 162 of the Journal of the Royal Society of Arts of January 2, 1925.

The growth of the rayon industry, as it is now known in the United States, and to which you refer in your article as the artificial silk industry, has, as you state, been tremendous in the past ten years, not only in this country, but elsewhere.

Ever since the Federal Trade Commission of the United States was created in 1914, business men in this country have gradually refrained from the use of misleading terms on their merchandise, and have endeavoured as nearly as it is possible to do so, to avoid mislabelling or misrepresenting their goods to the consuming public. We have tried also to secure legislation providing for the punishment of those misbranding their product, similar to that of the Merchandise Marks Act of Great Britain, which is in force in your country.

This gradual elimination of misleading terms brought about the realisation that "artificial silk" was not really, in the true sense of the word, silk, but a particular and distinctive product containing no genuine product of the silk-worm. In 1923, therefore, definite steps were taken to secure a generic term to designate what had been known as artificial silk, and after considerable time and energy had been spent on the part of many leading organisations in this country, the word "rayon" was finally chosen.

This name is fast gaining its particular niche in the hall of textiles, and has been adopted, among others, by the following, one of which is an important organisation in your country:—Silk Association of Great Britain and Ireland, Inc., National Retail Dry Goods Association (U.S.A.), Ohio Retail Dry Goods Association (U.S.A.), Boston Better Business Commission (U.S.A.), Associated Advertising Clubs of the World, the Viscose Company (U.S.A.), Silk Association of America.

It is hoped that within a short time Rayon will find its proper place in the family of textiles throughout the world, with wool, cotton, silk, etc., and that the old custom of referring to it as artificial silk will gradually be eliminated.

Ramsey Peugnet,
Secretary.

The Silk Association of America,
354 Fourth Avenue,
New York.

NOTES ON BOOKS.

A SHORT HISTORY OF BIRKBECK COLLEGE (UNIVERSITY OF LONDON). By C. DELISLE BURNS. London: University of London Press, Ltd. 5s. net.

In this volume Mr. Delisle Burns has not only given the history of Birkbeck College; he has thrown a curious—almost incredible—light on the manner in which popular education was regarded a hundred years ago. Birkbeck College, or the London Mechanics' Institution, as it was originally called, was the outcome of a genuine craving among the "working classes" for some sort of education. It was founded at a meeting held in 1823 at the Crown and Anchor Tavern in the Strand. More than two thousand persons were present, among them numbers of respectable mechanics. "A few of those who had come in were excluded as drunk, but the rest were serious and enthusiastic." Over this meeting Dr. Birkbeck—a successful London physician, who was enthusiastic in securing the spread of scientific knowledge among those working in trade and industries—was called upon to preside.

It is difficult to conceive the fierce opposition which this laudable movement met in certain quarters. *Bell's Weekly Messenger*, for instance, was horrified at the revolutionary idea of education for the workers in industry, and the awful effect of mathematics was said to be well known, for "the unhappy scepticism in France has been justly ascribed to this cause." The *St. James's Chronicle* was even more bitterly hostile. "A scheme more completely adapted for the destruction of this empire could not have been invented by the author of evil himself than that which the depraved ambition of some men, the vanity of others, and the supineness of a third and more important class, has so nearly perfected. It is nothing to the purpose to tell us that Mr. Brougham, or Dr. Birkbeck, or Mr. Huskisson cannot design the ruin of the country. Protesting against being understood to acquiesce in this assumption of the lawyer's or doctor's integrity or the minister's wisdom, we say that, whatever their motives may be, every step which they take in setting up the labourers as a separate or independent class is a step taken, and a long one too, towards that fatal result. Catiline and Cæsar had different objects, but they pursued their objects by the same means, the severing of the lower classes from their superiors, and this means, as usual, tended to the same result. Mr. Brougham wishes, perhaps, for merely political purposes to court a noisy mob on his side; Dr. Birkbeck's motive may be purely professional; Mr. Huskisson's no more than innocently pedantic: they are all three, however, scattering the seeds of evil, the extent of which the wisest amongst them cannot anticipate."

In spite of this opposition the London Mechanics' Institution not only got founded, but soon attracted a large number of students. A year after its birth it could boast a roll of 1,300 mechanics, of whom "nearly 1,000 had paid their subscriptions." The subscriptions, however, were necessarily small, and at first lectures and classes were held at Monkswell Street Chapel and at the houses of members, but in 1824 a house was secured in Southampton Buildings. This continued to be the home of the College until 1885, when the present buildings in Fetter Lane were opened by the Prince of Wales. After certain ups and downs in its career, the College has continued to flourish until it has now almost outgrown its present premises. In the quality of its work also, the growth has been equally noticeable, and in 1920 the hopes of its friends were realised when the College was admitted a School of the University of London in the Faculties of Arts and Science.

Rice: Its Cultivation and Preparation. By C. E. Douglas, M.I.Mech.E. London: Sir Isaac Pitman & Sons, Ltd. 3s. net.

It is somewhat remarkable that although, less than a year ago, there was no book devoted to the important subject of rice, two such works have now been published. The *Journal* of July 4th, 1925, contained a notice of "Rice," by Professor E. B. Copeland, of the College of Agriculture, University of the Philippines. This was an admirable and exhaustive treatise, which dealt with the subject largely from the point of view of economic botany. Mr. Douglas's little volume makes no pretence of comparing with the much larger work. It is a text-book suitable for the general grower of rice, and for those who take an intelligent interest in the great industries of the world. Without going deeply into any particular aspect, it gives an admirable conspectus of the whole subject. Few people realise how vast the subject is. Rice probably forms the staple diet of the majority of the human race, and the normal annual production is estimated at four hundred and forty billion pounds.

Mr. Douglas draws attention to the fact that although the British Empire produces nearly forty per cent. of the world's total crop, and Great Britain consumes some 160,000 tons of finished rice annually, an infinitesimally small proportion is dealt with by millers in this country, while nearly forty per cent. is imported from the Continent. Half a century ago there were a good many rice mills in London and in Liverpool, but the trade has been lost to us because handling and general labour charges are lower in certain European ports than in this country.

Modern Masters of Etching: Anders Zorn. Introduction by Malcolm C. Salaman. London: The Studio. 5s. net.

The third volume of this admirable series continues to fulfil the promise of its two predecessors. Here we have twelve of Zorn's masterpieces, excellently reproduced. Perhaps the most interesting of them all is the portrait of Ernest Renan. At the time when this etching was done Renan was old and almost dying, and he could only give the artist a sitting of one hour; but it is amazing to find what a wealth of character Zorn has realised and transferred to his plate in this brief space. The work is, as Mr. Salaman says, "one of the greatest etched portraits of all time, worthy to stand beside Rembrandt's greatest, and Van Dyck's and Whistler's." Two other superb portraits are "Madonna," a beautiful peasant woman nursing a baby, and "Mona," a singularly striking and dignified presentment of the artist's mother.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock, unless otherwise announced:—

March 25.—**Henry G. Dowling**, Chief Decorative Adviser, Messrs. John Line and Sons, "Wall-papers."

April 1.—**William Nunn**, late Adviser to the Siamese Government on Customs and Excise, "Siam: its Progress and Possibilities." **Byron Brenan**, C.M.G., will preside.

April 22.—**Cedric Chivers**, "Bookbinding." **J. M. Dent** will preside.

April 29.—**Lieut.-Colonel Andrew Balfour**, C.B., C.M.G., M.D. (Edin.), B.Sc., D.P.H., F.R.C.P.E., "The Trend of Modern Hygiene."

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, MARCH 23..Geographical Society, 135, New Bond Street, W., 8.30 p.m. Mr. F. G. Binney, "Across North-East Land."

Victoria Institute, Central Buildings, Westminster, S.W. 4.30 p.m. Mr. W. J. Bryan, "Man and the Divine Image."

Architectural Association, 34, Bedford Square, W.C. 8 p.m. Mr. C. Marriott, "Architecture in Painting."

Swiney Lecture, King's College, Strand, W.C. 5.30 p.m. Dr. W. T. Gordon, "The Geological History of Plants." (Lecture IX.)

Victoria League, 22, Eccleston Square, S.W. 5 p.m. Lt.-Col. H. M. Hole, "Rhodesia."

Electrical Engineers, Institution of, (Informal Meeting), 7 p.m. Mr. R. Grierson, "Panel Heating."

(N. Eastern Centre), at the Mining Institute, Newcastle-on-Tyne. 7.15 p.m. Colonel T. F. Purves, "The Post Office and Automatic Telephones."

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. A. E. Richardson, "Some Famous London Bridges."

City of London College, White Street, Moorfields, E.C. 5.30 p.m. Lecture on "American Trade."

East India Association, Caxton Hall, Westminster, S.W. 3.30 p.m. Lieut.-Col. Sir Armine B. Dew, "Frontier Problems and Defence."

TUESDAY, MARCH 24..Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C. 4 p.m. Mr. C. F. Swynnerton, "The Problem of the Tsetse Fly."

Civil Engineers, Institution of, Great George Street, W.C. 6 p.m. Mr. P. W. Robson, "The Large Water-Tube Boiler."

Anthropological Institute, 52, Upper Bedford Place, W.C. 8.15 p.m. Sir Aurel Stein, "Innermost Asia: its Geography as a Factor in History."

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. A. S. Eddington, "The Internal Constitution of the Stars." (Lecture I.)

Electrical Engineers, Institution of, (Midland Centre), Hotel Metropole, King Street, Leeds. 7 p.m. Mr. H. W. Clothier, "The Design of Electrical Plant, Control Gear and Connections for Protection Against Shock, Fire and Faults."

(E. Midland Sub-Centre), at the University College, Nottingham. 6.45 p.m. Major E. I. David, "Electricity in Mines."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. J. F. Young, "Perspective."

Brewing, Institute of, (Scottish Section), Caledonian Station Hotel, Edinburgh. Mr. R. H. Hopkins, "Contributions to our Knowledge of the Influence of Hydrogen Ions in Brewing."

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. A. C. Seward, "Botany." (Lecture II.)

WEDNESDAY, MARCH 25..United Service Institution, Whitehall, S.W. 3 p.m. Air Marshal Sir John Salmond, "The Air Force in Iraq."

Swiney Lecture, King's College, Strand, W.C. 5.30 p.m. Dr. W. T. Gordon, "The Geological History of Plants." (Lecture X.)

Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

Automobile Engineers, Institution of, 244, Deansgate, Manchester, 6.30 p.m. Mr. A. F. Burstall, "Experiments on the Power and Efficiency of a High Speed Gas Engine."

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Joint meeting with other Societies who are co-operating in Heat Engine Trials. Mr. W. H. Patchell, "A Standard Code for Tabulating the Results of a Steam-Generating Plant Trial."

Microscopical Society, 20, Hanover Square, W. 7.30 p.m. (1) Dr. J. A. Murray, (*a*) "The Making of Microscopical Preparations," (*b*) Imbedding and Section-Cutting. (2) Prof. P. Groom, "The Microscopical Investigation of Fungal Attacks on Wood." (3) Messrs. A. P. H. Trevelli and R. P. Loveland, "The Application of Microscopy to the Photographic Industry."

University of London Anthropological Society, at the London School of Economics and Political Science, Houghton Street, W.C. 4.30 p.m. Mr. H. J. E. Peake, "Anthropology in the Village."

THURSDAY, MARCH 26..Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 5.30 p.m. Dr. Eckener, "Modern Zeppelin Airships."

Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p.m.

Royal Institution, Albemarle Street, W. 5.15 p.m. Mr. T. T. Baker, "Chemical and Physical Effects of Light." (Lecture I.)

Victoria and Albert Museum, South Kensington, S.W. 6 p.m. Mr. H. L. Wellington, "The Ionides Collection."

Textile Institute, 33, Bloomsbury Square, W.C. 7 p.m. Mr. E. Wigglesworth, "Thread, Twine, Cordage and Rope."

London County Council, at the Geffrye Museum, Kingsland Road, E. 7.30 p.m. Mr. C. Spooner, "Design and Construction of Modern Furniture."

Mechanical Engineers, Institution of, (Scottish Centre), at the Royal Technical College, Glasgow. 7.30 p.m. Discussion on "The Second Report of the Marine Oil-Engine Trials Committee."

Auctioneers' and Estate Agents' Institute, 29, Lincoln's Inn Fields, W.C. 7.30 p.m. (London Junior Members' Meeting). Mr. A. W. Monahan, "Domestic Architecture."

Brewing, Institute of, (N. of England Section), Midland Hotel, Manchester. Mr. F. M. Maynard, "Reducing Science to Practice in the Brewery."

FRIDAY MARCH 27..London County Council, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 6 p.m. Lecture on "Modern Movements in Education."

Engineering Inspection, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 7.45 p.m.

Royal Institution, Albemarle Street, W. 9 p.m. Sir Ernest Rutherford, "Studies of Atomic Nuclei."

Sanitary Institute, Town Hall, Leicester. 3.30 p.m. Discussion on "Maternity and Child Welfare Work." 5.30 p.m. Mr. F. G. McHugh, "Smoke Abatement." 8 p.m. Popular Lecture by Prof. H. R. Kenwood, "Healthy Living and Facts and Fads."

Engineers, Junior Institution of, 39, Victoria Street, S.W. 7.30 p.m. Mr. A. P. Morris, "Irrigation Engineering in Burma."

Mechanical Engineers, Institution of, (Informal Meeting), Storey's Gate, Westminster, S.W. 7 p.m. Discussion on "The Cutting of Heavy Steel Sections."

(N. Western Branch), 9, The Temple, Dale Street, Liverpool. 7.30 p.m. Joint Meeting with the Liverpool Engineering Society. Discussion on "The Second Report of the Marine Oil-Engine Trials Committee."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. H. Felton, "The Thames."

English Goethe Society, King's College, Strand, W.C. 8.15 p.m. Miss E. Purdie, "German Influence on the Literary Ballad in England during the Romantic Revival."

SATURDAY, MARCH 28..Royal Institution, Albemarle Street, W. 3 p.m. Prof. J. H. Ashworth, "Nervous System of Ciliate Protozoa." (Lecture I.)

London County Council, at the Horniman Museum Forest Hill, S.E. 3.30 p.m. Mr. H. N. Milligan "Living Animals of the Sea Shore."

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FRIDAY, MARCH 27, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

WEDNESDAY, APRIL 1ST, at 8 p.m. (Ordinary Meeting.) WILLIAM NUNN, late Adviser to the Siamese Government on Customs and Excise, "Siam: its Progress and Possibilities." BYRON BRENAN, C.M.G., will preside.

FIFTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 18TH, 1925. MR. J. DUDLEY JOHNSTONE, President, Royal Photographic Society, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Antaki, Emile, Fallowfield, Manchester.
Clarke, Bertrand R., B.A., New York City, U.S.A.
Goonetilleke, S. A., Wattala, Ceylon.
Lovibond, Mrs. Frances Elizabeth, Salisbury.
Rickerby, John, Gateshead.

The following candidates were duly elected Fellows of the Society:—

Crerar, Lieut.-Colonel Robert, O.B.E., Enfield, Middlesex.
Crossland, Ernest Milling, Manchester.
Deanesly, Henry, Terenure, Co. Dublin.
Harding, A. Leigh, Wallington, Surrey.
Landrum, W. W., D.D., Russellville, Kentucky, U.S.A.
Mew, Henry Bertram, Huntingdon.
Niels n, Harald, London.
Rogers, Robert, Southampton.
Whitaker, Major George Cecil, London.
Whitaker, Mrs. Margaret, London.
Woodbury, Edward Berkeley Charlton, London.

A paper on "The Friese-Greene Process of Colour Cinematography" was read by Mr. Claude H. Friese-Greene.

The paper and discussion will be published in a subsequent number of the *Journal*.

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "Modern Colour Problems," by Louis C. Martin, D.Sc., A.R.C.S., D.I.C., F.R.A.S., Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and Technology, have been reprinted from the *Journal*, and the pamphlet (price 2s.) can be obtained from the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures which have been published separately and are still on sale can also be obtained on application.

PROCEEDINGS OF THE SOCIETY.

ELEVENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 18TH, 1925.

SIR NAPIER SHAW, LL.D., Sc.D., F.R.S., in the Chair.

THE CHAIRMAN, in introducing Dr. Owens, said the lecture dealt with a subject which was of interest to everybody, and one which had been deeply impressed upon people by the recent vagaries of the atmosphere. Since 1912 the matter had been under investigation by a Committee appointed by an International Conference, of which Committee Dr. Owens had been Secretary and the moving spirit from the beginning. In relation to its opportunities it had been more productive than any other Committee with which he had been associated. Dr. Owens possessed an extraordinary qualification for dealing with the subject of atmospheric pollution, in that he was both a Doctor of Medicine and a consulting engineer. He doubted whether a similar combination could be found in the whole of the Medical Register, or in the list of members of the Institution of Civil Engineers; and when one thought of it, that was exactly the combination which was required in order to get a successful line of attack upon the problem of atmospheric pollution.

The paper read was :—

MODERN ATMOSPHERIC CONDITIONS,

WITH SPECIAL REFERENCE TO LONDON.

By DR. J. S. OWENS, M.D., Assoc.M.Inst.C.E., F.G.S.,
Superintendent, Advisory Committee on Atmospheric Pollution, Air Ministry, Meteorological Office.

In prehistoric times our ancestors made their fires of wood; they were little troubled by pollution of the air as, living in small isolated communities of a few huts, smoke mattered little to them provided it got out of the hut. There were not a great number of fires and the wind soon cleared away their smoke.

In later times, that is, sometime before 852 A.D., coal began to come into use, and there are records of coal mining in the books of the Bishop of Durham in 1180 A.D. We have the smoke nuisance well established in 1257 and it remains until the present day. So far as smoke production from domestic coal fires is concerned, the primitive methods of our ancestors also survive.

The evil of atmospheric pollution has crept on us almost unawares, with the increase in the use of raw coal. The gradual growth of population and collection of people into monstrous cities have gone on until now the number of fires concentrated in small areas is so great that the air over our cities is like the inside of a huge chimney.

In the early Norman era the fires were made in holes in the middle of the huts, which were of wood ; it was only in the massive walls of castles that such luxuries as chimneys could be built.

There were holes in the roofs of the huts of the common people to let out the smoke. We, being more enlightened, insist on chimneys to carry the smoke outside the houses, but what happens to it then we leave to Providence ; and so it often comes back again through doors and windows dignified, when dense enough, by the name in the city of " London Particular."

There are two fundamental causes for the existing state of affairs ; the first—already mentioned—the collection of people into enormous cities, while the second arises from the existence in our country of immense beds of soft, smoky coal.

It is very difficult to get a true view of the condition of affairs which has come into existence so gradually ; hence it is only by an effort that we can appreciate the present appalling state of the atmosphere in our cities. Indeed, it is usually necessary to compare them with cities of other countries more fortunately situated or in which greater care is taken of the air the inhabitants have to breathe and live in, before we can appreciate the state we have arrived at.

To get a true insight into our modern atmospheric conditions it was necessary to devise methods of examination, and in 1912 a "Committee for the Investigation of Atmospheric Pollution " was formed as a result of a resolution which the author had the honour of proposing at the International Smoke Abatement Exhibition in London.

Measurements of atmospheric impurities had already been made in a few places : W. J. Russell in London, 1885[1] ; Cohen in Leeds, 1897[2] ; Irwin in Manchester, 1902[3] ; Harris in Glasgow, 1906 ; Cohen in Leeds, 1907-08[4] ; Des Voeux and Owens with the " Lancet " 1910-11[5] ; while the great work of Aitken in connexion with condensation nuclei, often incorrectly called dust, is well known.

There was, however, a need for more systematic examination of atmospheric conditions and some of the methods used by the Advisory Committee on Atmospheric Pollution, and the results will now be briefly described. The Committee has accumulated a vast amount of data on the quantity and nature

[1] Monthly Weather Report, August 1885.

[2] Journal of Society of Chemical Industry, 1897.

[3] Journal of Society of Chemical Industry, 1902.

[4] Cohen and Ruston. Smoke—A Study of Town Air.

[5] Lancet. Sootfall of London. January 6th, 1912.

of impurity in different places. Nine Annual Reports have been published dealing with about forty different stations.

DEPOSIT FROM THE AIR.

As this was the easiest thing to measure and promised valuable information it was tackled first and a standard deposit gauge evolved. This was simply a form of magnified rain gauge in which all matters deposited were caught and transferred to bottles underneath. The deposit was collected monthly, weighed and divided into insoluble and soluble matter; the former was then divided into tar, insoluble carbonaceous and ash, while the soluble matter was divided into loss on ignition and ash. A further analysis was made of the soluble matter into sulphates, chlorine and ammonia.

Table 1 shows the nature of the deposit from the air at a few selected stations. The figures are mean monthly deposit in tons per square mile, so that the annual deposit would be twelve times as much.

You will note that the total mean monthly deposit varies from 78.77 at one station to 4.65 at another. The carbonaceous or sooty matter is mainly smoke, but includes vegetable dust, while the tarry matter is entirely a product of smoke. It is this which gives the sticky quality to the deposited impurity in our cities. Domestic smoke shows anything from 20% to 40% of tar, while factory smoke has usually under 1%; thus the percentage of tar in the deposit gives an indication of the proportion of domestic to factory smoke, but it is not a very safe guide. The corrosive quality of the deposit is due mainly to the sulphur, and you will observe that there appears to be almost an inverse relation between the amount of sulphur and the amount of total deposit. This will be referred to later.

In Table 2 figures are given for London and Glasgow, showing the deposit from 1915 to 1924. This illustrates the great improvement in the condition of the air in both these cities which has resulted since 1915. The deposit in London in 1924 was only 59% of that in 1916, while in Glasgow the deposit in 1924 was 66% of that in 1916. The sooty matter and the tar are the parts of the deposit which make London and many other cities so gloomy to look upon, while the sulphur is the corrosive agent which attacks our buildings, rotting the stone and corroding the metal work.

RAIN AND DEPOSIT.

It has been thought by some that the amount of deposit trapped depended upon the rainfall; therefore a careful investigation of this was made when sufficient data were in hand. The deposit for a group of stations was plotted against the rainfall for the year ending 31 March, 1919. When this was done a somewhat curious result was obtained:—While the deposit of insoluble matter showed no relation whatever to the rainfall, that of soluble matter showed a definite and almost direct relation, a greater amount of soluble matter coming

Table I. Composition of Deposit at Five Representative Stations, given as:—(*a*) English Tons per Square Mile and (*b*) Percentage of Total Deposit. Both (*a*) and (*b*) based on Mean Monthly Deposit in a Year.

Station.	Tarry Matter.		Carbonaceous or sooty matter.		Mineral Matter insoluble in water.		Combustible or volatile matter soluble in water		Mineral Matter soluble in water.		Total Solids.		Sulphates as SO_3.		Chlorine as Cl.		Ammonia as NH_3.	
	Tons per sq.m	%	Tons per sq.m.	%	Tons per sq.m.	%	Tons per sq. m.	%	Tons per sq.m.	%	Tons per sq.m	%	Tons per sq.m	%	Tons per sq.m	%	Tons per sq.m	%
Oldham 1915-16	0.56	0.71	16.39	20.08	41.85	53.20	6.16	7.80	13.81	17.50	78.77	100	6.53	8.30	2.27	2.86	0.46	0.58
Sheffield (Attercliffe) 1914-15	0.72	1.31	9.61	17.60	23.71	43.50	4.58	8.40	15.93	29.30	54.55	100	7.25	13.30	4.02	7.33	0.20	0.38
London 1915-16 average of 8 stations	0.29	0.76	5.89	15.60	13.65	36.20	5.07	13.40	12.89	34.10	37.79	100	5.48	14.50	1.74	4.70	0.26	0.70
Malvern 1915-16	0	0	0.38	8.25	0.67	14.30	1.25	26.90	2.33	50.00	4.65	100	1.07	23.00	0.50	10.70	0.04	0.82
Manchester 1915-16 average of 5 stations	0.13	0.41	4.30	13.57	12.13	38.27	3.38	10.66	11.76	37.09	31.69	100	4.79	15.11	1.31	4.13	0.13	0.40

TABLE 2. Mean Monthly Deposit for the Six Months ending March 31st, in English Tons per Square Mile.

	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924
London (average of all stations)										
Total Solids	35.66	40.86	35.99	34.20	36.81	28.03	23.27	25.57	24.96	24.14
Tar	0.28	0.36	0.38	0.23	0.31	0.26	0.49	0.31	0.26	0.26
Carbonaceous or sooty matter ..	5.02	6.50	5.27	4.33	5.53	4.61	5.78	5.50	4.66	5.02
Sulphates	7.50	7.01	6.60	6.40	7.86	4.41	2.69	2.79	3.23	3.12
Glasgow (Blythswood Square)										
Total Solids	—	46.28	35.23	37.45	40.11	30.18	31.79	—	25.57	30.77
Tar	—	0.79	0.41	0.44	0.49	0.20	0.49	—	0.19	0.49
Carbonaceous or sooty matter ..	—	6.20	6.27	5.48	7.22	2.82	6.47	—	3.56	4.68
Sulphates	—	11.39	7.06	8.78	8.04	5.42	5.17	—	4.35	4.53

down with the heavier rainfall. Calling the rainfall in millimetres R and the soluble deposit in tons per square kilometre S, the relation was given fairly well by the expression :—

$$S = 0.069R + 2$$

Another group of nine stations over a period of four years showed the relation :—

$$S = 0.081R + 1.5$$

The inference apparently is, that while we may expect a small and fairly constant deposit of soluble matter during the dry weather this is rapidly increased by rainfall. Remembering that condensation in the atmosphere occurs on nuclei it is practically certain that it will exercise a selective action by picking out the soluble matter, especially if hygroscopic, while leaving the sooty or tarry matter, which is non-hygroscopic. Thus the above result is not an unexpected one.

Of course, the deposit of soluble matter could not go on increasing indefinitely with the rainfall, as the supply would run out; but judging from the above results there is a sufficient supply for all ordinary rainfall in this country.

SUSPENDED MATTER—AUTOMATIC RECORDER.

Having measured the deposit this told us nothing of the impurity remaining in suspension; therefore a method of measuring this was evolved. Briefly, it consists of an automatic instrument which filters two litres of air at intervals through white filter paper, the resulting discoloured spot being used as a measure of the quantity of impurity. The method is quite satisfactory for city air where the impurity is black, and some very interesting results have been obtained. As these have been described fully elsewhere they will be referred to only very shortly here. When an hourly average for a number of days in London is taken the concentration of suspended matter is found to go through a fairly regular cycle of variations, apart from days in which there is a dense smoke fog or haze, Fig. 2. Starting from midnight the air is comparatively pure until about 5 a.m., when the impurity commences to increase slowly. At about 7 a.m. on weekdays it begins to rise rapidly reaching a maximum in the forenoon somewhere about 10 o'clock, depending upon the time of the year. It then begins to fall steadily again until about 6 o'clock in the afternoon, when there is a slight rise, followed by another fall to midnight. This is repeated day after day with little variation except on Sundays, when the maximum in the forenoon is delayed about an hour. By plotting a curve of impurity on a time base the area under the curve represents the quantity produced during the day, and by comparing the areas of Sunday with weekday curves we get a good idea of the relative amount of domestic and industrial smoke. The relation for Westminster and South Kensington obtained thus is about 1 industrial to 2½ domestic. It is quite different in other cities and no general inference can be drawn from these figures. In making such an estimate it was necessary to exclude all days on which there was an abnormal quantity of impurity present due to banking up.

To illustrate the information given by curves of impurity plotted from the results of this instrument we may refer to a few cases :—

In Glasgow the distribution was very similar to London except that the falling off in the afternoon on weekdays was not so well marked and the lag of one hour in the Sunday maximum was more definite.

Curves for Blackburn prepared from 269 days show an hourly distribution somewhat similar to other cities but with marked peculiarities. The rapid rise in the mornings begins in the summer about 4 a.m., and reaches its maximum on weekdays and Saturdays at 7 a.m., while on Sundays the maximum is delayed until about 10 a.m. This suggests a good long spell off on Sundays but very early rising on weekdays. Again, there is a curious second maximum on weekdays and Saturdays between 10 and 12 in the forenoon, but there is no second maximum on the Sunday curves. This points to industrial smoke as the cause of the first maximum. Further support is given by the fact that the second maximum is higher than the first on winter weekdays, while in the summer the first is higher than the second, the domestic fires being out of use in the summer.

Records from Stoke-on-Trent show a very curious distribution. While there is the same rise about 4 a.m. on weekdays and 5 a.m. on Sundays, on summer weekdays the maximum is reached between 7 and 8, but on the winter weekdays it is delayed until between 8 and 9 o'clock ; also on Sundays in the winter the maximum is not reached until about mid-day. In the afternoon the impurity is maintained at a high level during the whole period with remarkable oscillations, and the amount of impurity on Sundays is very little less than on weekdays. In Stoke the pottery ovens no doubt govern the quantity of smoke, and they are not operated with the same regularity as, for example, boiler furnaces. A curious thing observed in the Stoke curves was that the Saturday forenoon maximum was the highest of all, and on enquiry the author was informed that there was a custom of lighting ovens on Friday night or Saturday morning.

DAILY INCIDENCE.

Passing now to the daily incidence of suspended impurity it is found that there is a general tendency for the quantity of impurity in the air to diminish towards the end of the week and have its maximum towards the beginning. For some curious reason there appears to be a maximum number of smoke fogs in London on Wednesdays, with a minimum on Saturdays.

SUSPENDED MATTER—DUST COUNTER.

The filter method does not admit of microscopic examination of the suspended impurity, nor is it applicable to impurity other than smoke, except with special coloured paper. For these reasons another instrument was evolved by which a sample of suspended dust could be obtained under such conditions as to admit of counting the dust particles and examining them microscopically or microchemically. The instrument has been fully described elsewhere.[6]

In it a ribbon shaped jet of air is caused to strike a microscope cover glass at such a high velocity that there is an adiabatic expansion of the air in the jet, with accompanying cooling and condensation of water if present. This water acts as an adhesive when the jet strikes the cover glass, and the dust particles impinging remain upon the glass as a linear trace. The condensed water re-evaporates as the air flows away sideways with a lower velocity. To make sure that there is always sufficient water to condense, the approach to the jet is through a chamber the walls of which are lined with damp blotting paper.

By the aid of this the number of dust particles suspended per cubic centimetre can be counted and the particles themselves examined as to size, nature, shape and so on. Much curious information is given from the examination of records obtained in this way; for example, the author obtained in Norfolk records from the wind which had blown across the North Sea. These contained up to 200 particles of dust per cubic centimetre.

Again, dust records taken outside Spurn Head on September 11th, 1922, showed 140 dust particles per cubic centimetre, while on the same day in Hull there were 13,800. In London the number of particles per cubic centimetre during a thick smoke haze or fog rises to 80,000 or 100,000 per c.c., while during an ordinary winter day the number is usually about 4,000 or 5,000. The particles of soot which form this haze in London are usually not over 1 micron in diameter, the average size being about 0.7 to 0.8 micron. They are usually irregular in shape but sometimes the author has found that they were nearly all kidney shaped for some strange reason. In addition to the particles of soot there are nearly always a small number of perfectly spherical glassy-looking particles. These are sometimes clear, sometimes coloured yellow or red, and are doubtless mainly derived from the fused ash from fires. They are usually from a little over 1 micron in diameter down.

When a smoke haze in London is very dense the diameter of the particles composing it is found to be greater than during less dense haze, rising to a maximum of about 2 microns. It would appear that the rate at which the smoke collects is too great for the usual grading by settlement to take place.

Sometimes mould cells are found; these were discovered in great numbers in the autumn when the leaves were falling. It was inferred that the dead leaves provided suitable material for moulds to grow upon, and cells identical with those found in the air were obtained from a few dead leaves kept in a damp box over a slide.

There is another method of using this instrument which can give additional information. When the damping chamber is held in the hand so as to vaporise a little more water than usual, and a heavy record is made by drawing a large volume of air through the jet, stream beds are found on the sides of the dust trace where the excess water has been blown sideways, and in the dried-up heads of these stream beds the soluble matter from the dust is often found in the form of crystals. It is not always easy to identify these crystals as they are usually excessively small and mixed with other materials.

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[6] Proc. Roy. Soc. Vol: 101. A. 1922, and 8th Annual Report Advisory Committee on Atmospheric Pollution.

Again, by taking dust records upon prepared cover glasses having some suitable chemical indicator, such as methyl orange, distributed over the surface in fine crystals the condition of the dust as to acidity or alkalinity can be ascertained by the change in shape of the indicator crystals.

SPECIAL DUST RECORDS.

A record taken in Algarve in the south of Portugal during a light, bluish haze, was found to consist entirely of crystals of common salt. Only one other similar record has been obtained by the author and that was last August in the mouth of the St. Lawrence River. There was a white haze and this was found also to consist almost entirely of salt crystals.

Three records were taken on July 28th last, in mid-Atlantic, with precautions to avoid dust from the ship, and on none of these was any dust found. A fourth record taken about the same time showed a few crystals. There had been a fog off and on all day but at the time of taking the record it was clear.

On July 30th also, mid-Atlantic records were again taken during a slight mist with wind from north-west. These showed a few crystals, probably of common salt, and some yellowish needle-shaped crystals, but no dust particles.

While crossing Lake Ontario on August 5th last, a haze similar in appearance to that found at the mouth of the St. Lawrence was observed, but this was composed of ordinary dust or smoke particles, about 180 per cubic centimetre, with a few needle-shaped and other crystals, doubtless smoke from the cities round the Lake and the Lake steamers.

Observations made last summer in the Sud Express on the journey from Paris to Madrid showed 13,000 particles of dust per cubic centimetre, no doubt smoke from the engine and dust from the interior of the carriages.

In Madrid the dust traces were found to be quite different from those in London and other English cities. There was evidence of a fair number of smoke particles. The count gave about 420 per cubic centimetre at 9 o'clock in the morning, rising to 2,500 per cubic centimetre at 7.20 p.m., but the increase in the number was evidently due to dust from the ground, as the particles were mostly large and irregular in shape, with a diameter from 2 to 5 microns.

Other observations will be referred to later, but these are intended to give some idea of the nature of the results obtained.

We will now consider the London atmosphere in particular although it may be taken as typical of large cities where a considerable amount of smoky coal is burnt without any special effort to reduce the smoke emitted, at least from domestic fires.

THE ATMOSPHERE OF LONDON.

Let us compare the London atmosphere with what it ought to be:—The air should be clean and transparent. If it is not transparent the sunlight cannot penetrate effectively and we know that something like 50% of the sunshine which London ought to get is cut off by its smoke pall. Similarly it has been shown by the Department of Applied Physics of the Medical Research Council that a large proportion of the ultra-violet radiation from the sun is also cut off. We will not discuss the importance of sunlight and more particularly of the ultra violet radiation; it is beyond question one of the essentials for health.

Instead of the air being clean it is turbid and full of suspended impurity. We should object to drinking turbid water but we do not seem to worry much over breathing turbid air; probably because we have got more or less used to it.

The air of London during a smoke fog contains countless millions of particles of soot and even on any winter's day is sufficiently heavily laden with impurity. So far from being clean it is contaminated with sulphur and with tarry matters, and when the conditions are such that a smoke fog settles over the city the amount of sulphur in the air rises rapidly until it exceeds four or five times the quantity in ordinary fine weather. The same applies to carbon dioxide; during a fog it rises from the normal of about three parts in ten thousand to thirteen or fourteen parts.

It is very evident, therefore, that we have in London an atmosphere which cannot be regarded as reasonably clean. The colour of our buildings is a good indication of the state of the air.

We may ask why it is that sometimes the smoke collects in an immense cloud over the city or down in the streets, and we get a typical London smoke fog, while at others the air, for London, is comparatively clear. London burns something like seventeen million tons of coal per annum, and, at least in the winter, the production of smoke does not vary much from day to day, so that we have thus a condition in which a steady production of smoke with little variation in its quantity results sometimes in a moderately clean air, while at others the city is enveloped in a thick cloud of smoke.

LONDON FOG.

It is necessary here to consider for a moment the meaning we are to attach to the word "fog," as there is much misconception arising from its use in different senses.

To meteorologists and sailors fog is a word applied to the condition when condensed water in the form of suspended globules in the air hinders good seeing. This is practically always due to cooling of the air below its dew point; so that some of the water held in the form of vapour is condensed. The cause of such cooling is for our present purpose unimportant. For such condensation to take place suitable nuclei for the molecules of water to collect around must be available, but these nuclei need not be dust particles in the ordinary sense of the word. The question of the influence of the nature of the nucleus upon the formation of fog is a somewhat recondite one. There is no doubt that if these nuclei consist of hygroscopic particles, such, for example, as sea salt or sulphuric anhydride, condensation will begin earlier than it otherwise would. Leaving this aspect, however, for the present, the point to observe is that fog in this sense consists practically of pure water and its formation depends primarily upon the cooling of air below its saturation point.

There is, however, another meaning and a more general one attached to the word, and that is any condition of the air in which numbers of suspended particles of any kind obscure vision. Thus we have the commonly used expression in London "a smoke fog." This use of the word in different senses is misleading, and it would be better if all obscurity due to suspended solid matter were referred to as haze, leaving the word " fog " to apply solely to the variety due to condensed water.

Now it is evident that if we talk of a London fog we are using an expression capable of several meanings and in this way much misconception arises as to causation and prevention of these phenomena. An attempt to explain London fogs as arising in the same general way and from the same causes, as, for example, sea fogs, is, in my opinion, incorrect, but the reason why such attempts are made is not far to seek since it is a remarkable coincidence that the presence of a thick fog of water particles over the country is usually accompanied by a thick smoke haze over London. Although this is true the conditions responsible for the country fog operate in a totally different way in bringing about a smoke haze. The importance of this in connexion with the London atmosphere will be apparent when we consider the effect of temperature :—Condensation fogs do not usually occur in cities when the temperature is over 40° F., and the wind over 2 miles an hour. With a slow drift of air over a city like London combined with the burning of enormous quantities of coal it can be shown that the temperature of the air over the city is likely to be raised several degrees above that in the surrounding country. In the observations made during a special fog enquiry in the winter of 1902-03 by Mr. Lempfert,[7] it was shown that there were great variations in temperature over the city, and maps produced in his report showed, in all cases a tendency for a higher temperature in the city than the surrounding country; for example, on March 11th, 1903, the temperature was 40° F. near St. Paul's, while at Wandsworth it was 32°F. Again, on November 13th, 1902, at 9 a.m., there were high temperature areas between 45° F., and 49° F. over the city, while on the south-west, the direction from which the wind was coming, the temperature was 33° F. at Kew. At 5 a.m. on the same day there

[7] London Fogs. Report of Meteorological Council, Official No. 160.

was an area varying from 46° F. to 48° F. over the city, while the temperature at Kew was 32° F.

The importance of this is seen when we remember that a water fog existing in a temperature of, say, 35° F. may be completely cleared by simply raising the temperature to 45° F. Saturated water vapour at 35° F. contains 2.366 grains per cubic foot, while at 45° F. it contains 3.414 grains; thus the water represented by the difference of these two figures may exist as suspended particles at 35° F. and be revaporised at 45°F.

We should therefore expect less fog of the water variety over London than over the surrounding country, and if we do not supply quantities of smoke to take the place of the water it may be taken that during widespread fogs over the surrounding country London would enjoy a clearer atmosphere.

CAUSE OF SMOKE FOGS.

Why does smoke collect during such fogs? The chief factor controlling this is the wind. When the wind drops to one or two miles an hour or a dead calm the smoke cannot get away. Therefore it is dammed up and collects in a pall over the city. Again, during widespread water fog there is always an inversion of the vertical temperature gradient so that instead of falling at a regular rate as the height above ground increases the temperature may begin to rise again at some height above ground. For example, during the fogs of December 10th and 11th last, observations at Kew Observatory[8] showed that on December 10th the temperature from the ground to about 300 feet was under 35° F., but between 300 and 400 feet, about the top of the fog, it jumped to over 45° F. Again, on December 11th, the temperature was a little over 30° F. up to about 600 feet to 700 feet, but then rose rapidly until about 700 it was just under 45° F.

Under these conditions the smoke rising from London cannot get above the level of the inversion. Thus we have two factors operating together:—The wind fails to carry the smoke away while the inversion of the lapse rate prevents its escape upwards, with the result that it all collects and we have our familiar experience of a " London Particular." It is worth observing that during a thick smoke haze in London and assuming an upper limit of 300 to 400 feet, there would be something like 200 to 250 tons of soot suspended over London. Further, and this is important, the whole of this soot can be produced in about three hours by the fires lighted on a winter's morning. Thus, if Nature's provision for scavenging fails for a few hours there is ample material for a dense smoke haze.

The popular conception of such a condition in London is that there must first be a water fog, and that the globules of water are condensed around smoke particles, while the outer surface of such globules becomes coated with a film of tarry oil, which is supposed to account for their failure to disappear by evaporation, although the air may not be saturated. This, the author believes, is an entire misconception, and therefore the following is put forward as a more satisfactory explanation and more in accordance with the facts. This is to the effect that the "London Particular" is caused by a more or less complete replacement of water particles by smoke particles, the water droplets being partially evaporated and their place taken by smoke. In support of this, which, being a new theory, therefore requires some support, the following observations are submitted :—

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[8] Meteorological Magazine. January, 1925.

(*a*) The author has several times found that in the country near Cheam, where he lives, a thick fog existed with a limit of visibility of 50 to 70 yards, and a comparatively small number of dust particles. On going to London the limit of visibility has, however, practically always increased up to perhaps 100 yards, while the number of smoke particles has also increased very greatly. Thus we have an improvement of visibility accompanying an increase in the number of suspended soot particles. This can only arise from a reduction in the number of suspended water particles.

(*b*) A record taken at Cheam on December 11th, with the dust counter already described, gave a count of about 4,000 to 5,000 soot particles per cubic centimetre of air. The record is formed on a cover glass by the impact of a ribbon-shaped jet of air and consists of a linear trace of dust. In the case referred to the dust trace showed numbers of lateral streams carried out from the side of the trace, due to the large amount of water present. On going to London, a second record was taken and the number of dust particles found then was approximately 27,000 per cubic centimetre, while there were no streams blown out from the side. Here then is evidence that the fog in the country contained a comparatively small amount of dust, but a large number of water particles, while in London there were fewer water particles and a large amount of dust or soot.

(*c*) When the sun is observed through a "London Particular," if visible at all, it appears as a red ball. The red colour is due to the scattering of light of short wave length at the violet end of the spectrum, while the red rays penetrate; but to scatter blue or violet light the suspended particles must not be more than about one-half of a micron in diameter, whereas the drops of condensed water in a fog are usually over 2 microns in diameter.[9] On the other hand the suspended particles of smoke found in the air usually average from 0.5 to 0.8 micron in diameter down.

It is evident therefore that the red sun must be due to these and would not appear if they were absorbed as nuclei for water drops.

(d) It is found that the parks in London often have a dense fog while in the streets and built-over part it is much less dense.

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[9] C. Barus. "Atmospheric Nucleation." Smithsonian Contributions to Knowledge. Vol. 34.

All these points indicate that the true explanation is as already suggested, that is, in London the water fog is partially evaporated by the higher temperature but its place is taken by smoke.

The bearing of all this upon prevention is evident, since one is driven to the conclusion that if smoke were not supplied to take the place of the water London would be more free from fog than its surroundings.

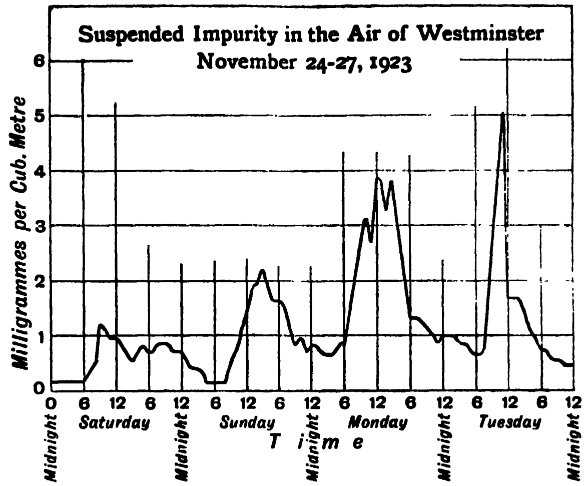

Fig. 1.

The accompanying graph (Fig. 1), reproduced from "Nature" 15. 12. 23. shows the quantity of suspended matter in the air of London during the dense fog of November 25th to 27th, 1923. It is important to observe the periodic rise and fall of the quantity of impurity. From Saturday till Tuesday the density got gradually worse, but made its peak of maximum intensity each day about mid-day, falling again to a minimum in the early morning. Compare this with a record of suspended impurity during ordinary winter days, such as shown in Fig. 2, for Westminster. Here we have the same period of minimum

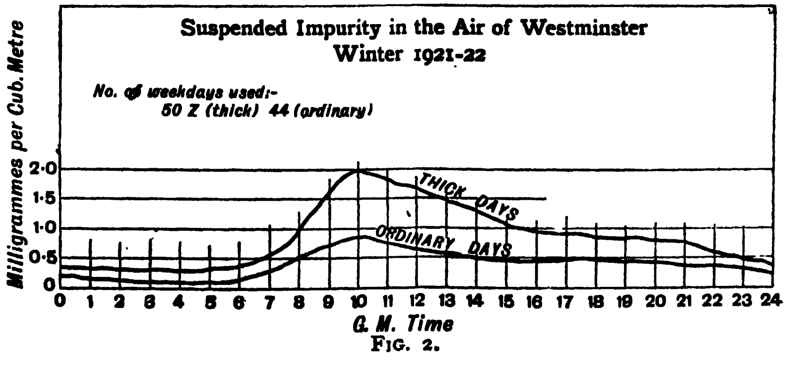

Fig. 2.

impurity in the early hours of the morning, the same maximum about mid-day and the same afternoon fall; the only difference is that during smoke fogs the conditions with regard to impurity become gradually worse, the smoke being prevented from escaping by failure of the ventilation over the city.

WIND.

Turning now to the effect of wind :—If we consider an ideal case of a single chimney emitting smoke into a stream line wind and if the concentration of the smoke be measured at a point down wind, it is evident that it will vary inversely as the wind velocity. If the wind is blowing at four miles an hour then one hour's smoke will be stretched over four miles. If it is blowing at one mile an hour the same amount of smoke will be stretched over one mile. Thus in the latter case it will be four times as dense. This is, of course, an ideal case, but serves to illustrate the profound effect the wind must have. In addition to the stretching out of the smoke down wind there is also a lateral spread and a spread in a vertical plane due to turbulence. We should, therefore, expect the smoke concentration to be some function of the wind velocity, assuming that the rate of production remained constant, and in order to examine this a curve has been prepared from records taken by an automatic instrument at Westminster during four winters and wind velocities at Kew, supplied by the Meteorological Office. The concentration of impurity is plotted as ordinates over the wind velocity as abscissae. This is shown in Fig. 3 and it is very remarkable.

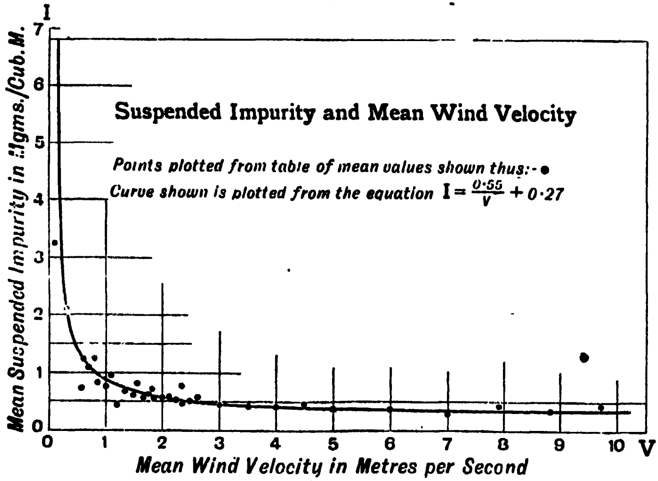

FIG. 3.

It is necessary to realise that it was only by the use of a large number of observations the irregularities became smoothed out. The point of observation, being at Westminster, was fairly centrally situated in the city; thus there was a large smoke-producing area on all sides, and, although not strictly correct, it was assumed that the amount of smoke produced in all directions round that point was the same. By making this assumption the effect of wind direction was eliminated, and although not strictly true it probably did not introduce any very serious error. Again, the quantities plotted for both wind velocities and impurity were averages for each day, and in connexion with the impurity figures it is to be noted that errors were probably also introduced by neglecting the lag in establishing steady conditions. For example, during very light winds the time required for smoke from the furthest points to reach the place of observation would be greater than during winds of greater velocity. Thus it is to be expected that the plotted points for low wind velocity would be somewhat more erratic than with the higher velocities.

Turning now to the figure, the curve drawn through the plotted points is not an attempt to draw a fair line through them but is a definite mathematical curve, the equation of which is :—

$$I = \frac{0.55}{V} + 0.27$$

I being the concentration of impurity in milligrammes per cubic metre and V the velocity of the wind in metres per second.

The remarkable thing about this curve is that it indicates a variation of concentration inversely as the velocity of the wind and not as some higher power of the velocity. To understand how this can be it must be remembered that the point of observation was in the middle of a large area acting as a source of smoke. Thus the lateral spread of the smoke with the wind was practically eliminated as it could only take place at the outer edge of the smoke-producing area.

With regard to the vertical spread, the absence of some evidence of this is more difficult to explain ; but it appears possible it may be due to the proximity of the point of observation to the source.

At any rate the points plotted show the actual results obtained and the mathematical curve drawn in fits these points extremely well. The equation given enables a fairly good forecast to be made of the smoke concentration to be expected with any particular wind.

The general inference to be drawn from such a curve is the profound effect of wind velocity, so that given a suitably low wind speed a smoke fog becomes almost inevitable under present conditions.

DESTINATION OF SMOKE.

We may now examine another interesting question :—Where does the smoke produced in great cities go to ? If we consider a single soot particle under 1 micron in diameter, it will settle through the air under the influence of gravity at an excessively slow rate, so slow indeed that if shot from the top of a chimney 100 feet high, the particle would take nearly three weeks to reach the ground in perfectly still air.

It is evident that a slight wind might drift it for a great distance before it reached the ground, and that it does so drift the smoke is shown by the fact that it can be detected in the air all over the country. The author has found large numbers of suspended particles in the air which had blown across the North Sea without touching land.[6] If the conditions are such that the individual particles of smoke remain separate and do not aggregate together into large bunches it may drift over hundreds of miles. This is the chief source of the beautiful blue haze which overspreads the country during anticyclonic weather in the summer. It gives what artists call an " atmosphere " to the landscape. Another evidence of the spread of smoke over the country is the decay of buildings, far removed from cities, due to the attack of sulphur acids upon the limestone. The existence of such decay is now well recognised in such buildings as Windsor Castle, Riveaulx Abbey, (Yorkshire), Tintern Abbey, and others.

During the fogs of December last the deposit of soot particles from the air in the neighbourhood of London was abnormally great. A miscroscope cover glass was exposed at Cheam, about 11 or 12 miles south-west of London, on the afternoon of January 11th last, for 20 minutes, and the number of particles which settled in this time was counted. Taking individual particles about ½ micron in diameter, these had settled at the rate of 70,000 to 80,000 per square centimetre per minute. It was obvious, however, that the settlement of many of these had occurred in aggregates or masses. There was a dense water fog at the same time and a quite abnormal amount of smoke pollution, amounting to 15,000 or 16,000 particles per cubic centimetre. The rate of settlement, however, was much greater than would be accounted for by settlement of individual particles. One of the results of this deposit was that the whole country the morning after the fog was covered with a black, oily looking layer, This was evident on the roads, while the pools of water had oily, iridescent films. The site of a mat on a verandah was marked by a square of comparatively clean tiles, while all around was much darker. In this case the smoke in its travels was depositing with unusual rapidity.

It is well to observe that the evils of smoke are by no means limited to the immediate neighbourhood of great cities, although more obvious there.

SELECTIVE DEPOSIT.

A somewhat remarkable result arrived at from the observations of deposited impurity made for the Advisory Committee at different stations in England will now be referred to. This suggests that the sulphur impurities derived from the combustion of fuel penetrate further into the surrounding country than does the solid sooty matter evolved at the same time. The deposit of sulphur, carbonaceous matter and total solids for three selected stations are shown in Table 3, and in a separate column the percentage of the total solids

TABLE 3. English Tons per Square Mile.

	Sulphates as SO3.		Carbonaceous matter.		Total Solids.		Sulphates as percentage of Total Solids.		Carbonaceous matter as percentage of Total Solids.	
	Summer.	Winter.	Sumsum.	Winter.	Summer.	Winter.	Summer.	Winter.	Summer.	Winter.
1917-18.										
London :—Golden Lane	30.8	28.4	35.2	38.4	202.2	195.3	15.3	14.6	17.4	19.7
Newcastle-on-Tyne	37.5	23.4	81.4	56.1	394.8	244.3	9.5	9.6	20.6	23.0
Malvern	11.7	8.1	3.1	1.1	47.5	32.6	23.9	24.9	6.5	3.3
1919-20.										
London :—Golden Lane	23.6	22.0	35.0	41.8	162.9	154.7	14.5	14.2	21.5	27.0
Newcastle-on-Tyne	—	24.4	—	47.7	—	190.7	—	12.8	—	25.0
Malvern	20.0	10.8	27.6	21.5	56.7	32.7	35.2	33.0	4.9	6.6
1920-21.										
London :—Golden Lane	19.0	22.2	45.4	42.6	180.2	170.3	10.5	13.1	25.0	25.0
Newcastle-on-Tyne	19.6	20.0	64.7	50.2	277.7	231.0	7.1	8.7	23.0	21.8
Malvern	6.3	10.7	24.6	21.5	28.9	48.8	21.7	22.0	8.5	4.4
1921-22.										
London :—Golden Lane	15.7	21.4	56.2	43.8	177.5	179.8	8.8	11.9	32.0	24.0
Newcastle-on-Tyne	19.2	21.6	66.3	78.2	283.3	263.1	6.8	8.2	23.0	30.0
Malvern	9.1	10.1	28.6	18.2	33.1	36.3	27.4	27.8	8.4	5.0

which is made up of sulphates and carbonaceous matter. The remarkable thing in these figures is the extremely high percentage of sulphates in the country at Malvern and the low percentage of carbonaceous matter. The station is at Malvern Wells, right in the country, and must be supposed to get its impurity from a distance. While the percentage of sulphates at Malvern is abnormally high compared with the city deposits the total quantity is in all cases less. It appears that there are some factors operating which enable the sulphur impurities to travel further than carbonaceous or insoluble dust. Another factor is, however, also affecting the results and must be kept in mind: The evolution of sulphur acids from fires and furnaces must be fairly constant in amount and quite independent of smoke emission. Thus when sulphur deposit is given as a percentage of the total it is to be expected that it will show a more or less inverse relation to the total. This has already been indicated in connexion with Table 1.

Referring to Table 3 and selecting the last year—1921-22—for the moment, the per centage of sulphates in the summer at Golden Lane, London, was 8.8, while at Malvern it was 27.4 On the other hand, the percentage of carbonaceous matter at Golden Lane was 32, while at Malvern it was only 8.4. Looking at the winter for the same year, sulphates at Golden Lane amounted to 11.9 per cent. of the total, while at Malvern they made up 27.8. Carbonaceous matter at Golden Lane amounted to 24 per cent. of the total, while at Malvern it only made up 5 per cent.

It appears, therefore, that as we move away from cities there is a gradual alteration in the composition of the deposited atmospheric impurity, and since the sulphur is the most injurious part, the impurity of the country air, although smaller in quantity than in the city, is, weight for weight, more corrosive and more injurious to vegetation than the city impurities. This is a point to be remembered by country dwellers:—How much their crops are affected by a drift of sulphur from the cities, and generally how much of the city impurity is passed on to the country?

REMEDIES.

With regard to the remedy, it is not proposed to deal with the technical problem of preventing smoke; the means are already sufficiently well known. All that is now really wanted to get rid of the trouble is a determination on the part of the people to do so. No doubt this statement will be severely criticised, but the criticism we often hear from people who do not desire to have their present methods interfered with carries about the same weight as the advocacy of others interested in some smoke-preventing device or fuel. Any of you who have taken the trouble must have noticed that industrial furnaces for steam raising are very often worked with little or no smoke production; while in other cases there is copious production of smoke, thus showing that it is possible to prevent smoke emission in any quantity. Again:—

Steel makers will say, "We must have a reducing atmosphere in our furnaces and smoke is an essential." Well, the author has seen several steel making and reheating furnaces operating on high carbon steel and having smoky flame in the furnaces but emitting little or no smoke from the chimneys. You will observe that the argument for a reducing atmosphere shows that smoke is necessary in the furnaces; but it does not show the need for emitting it from the chimneys.

Broadly speaking, the reduction of the intolerable impurities in the atmosphere of our cities is in our own hands, and, so far from being a hardship economically, it would result in a saving to the country. At the same time the life of our city dwellers and workers would be made reasonably fit for human beings.

DISCUSSION.

Sir Frank Baines, C.B.E., C.V.O. (Director of Works, H.M. Office of Works) said he had rarely listened to such a masterly exposition of so obscure a problem. It was a problem with which he himself had been peculiarly associated, from a very small aspect perhaps, namely, the serious effects of polluted atmosphere on the great buildings and monuments of the nation. One fact had been brought out by the author, namely, that the pollution of the atmosphere was primarily due to two causes. The first of those was the aggregation of masses of population in our cities. He could not contemplate the idea that that population would ever be dispersed into country districts, and, therefore, that cause of the pollution of the atmosphere would always remain. The second cause was the burning of raw or soft coal. There, again, he could not conceive the mass of the population of these islands ever giving up the radiant heat which they got from a raw coal fire; and although the author had pointed out quite clearly that smoke abatement was possible, and that pollution of the atmosphere could be improved if only civil engineers and mechanical engineers would tackle the problem in the ways known to science, yet any method of smoke elimination which did not apply to the domestic grate would hardly be effective. One appalling fact which had emerged from the paper was that domestic smoke was responsible apparently for from 20 per cent. to 40 per cent. of the tar content of the smoke. A point of very considerable hope, however, had been stated by the author, namely, that the condensation fogs were likely to be less over London than over the country. Therefore, there was a possibility that the atmosphere which hung over our cities would be preferable to the atmosphere which hung over our rural areas if we once eliminated smoke; that was to say, the condensation fog would be less over our great cities because of the increase of temperature due to the great mass of activity in our cities; and if we could only eliminate smoke and get an absolutely clean atmosphere, country people would come to our towns in order to get fresh air, and so the present conditions would be entirely reversed!

He had found, during his own very minor researches into the problem, that the question of smoke pollution had arisen as early as the 13th century. In connexion with his investigations of one of his buildings—Holyrood—he had found that there had been a definite utilisation of the outcrops of coal in the estuaries of the Forth, which had caused serious trouble. That showed that the problem to-day was very largely a repetition of the problem of yesterday. He had also found that

Evelyn, the great diarist, after the Restoration, had referred to what he called—and it seemed to be a very happy phrase—the "presumptuous vapours" which issued from the chimneys of Scotland Yard and which, he said, had such an appalling effect upon the Court that they had to retire to the country of Kensington to escape from them. It was evident, therefore, that the problem was quite an old one, but it was clearly up to the present generation, with its existing scientific methods, to find a cure; and he believed that Dr. Owens's masterly disquisition would cause more serious thought among the people of this country than probably any of the remarks of the diarist Evelyn.

As he had said, his own problem was primarily one of dealing with buildings. It was one which concerned the nation a little, because once those buildings and monuments were obliterated and ruined by atmospheric pollution the nation would lose that sense of tradition and history which was so vital to its apprehension of progress. Therefore, he did suggest that the problem was of primary importance historically. If we let this modern disease of society—this pest which had grown up since the industrial revolution—continue unlimited, the nation would inevitably lose the right to possess things of beauty such as our great abbeys, monuments, castles, pictures, glass, etc., etc. Everything would fall into decay. The almost unceasing and senseless energy of the industrial period of to-day was apparently producing within itself something which would obliterate itself, thus showing there was no survival value in activities of that kind if they produced a disease such as we were suffering from at present.

He had often wondered, in examining buildings, why evidence of the pollution of the atmosphere should be found deep in the body of the walls. In one of our great London buildings he had found forms of sulphate of calcium and sulphate of magnenesium as much as 17 to 18 inches away from the face of the stone. It was true that the sulphate was on a line of cleavage in the stone, but that line of cleavage was a very minute one. It was quite clear, therefore, that the sulphur content of the atmosphere dispersed in the form of sulphurous gases, which, in the particular case he was quoting, had entered 18 inches into the stone, had produced the crystals of sulphate of calcium and magnesium and had burst the stone as far back as 18 inches from the surface. The author had made a suggestion as to how that happened, namely, that the alternating barometric pressure in the atmosphere would in one case evacuate the air from the capillary tubes of the stone, and then re-enter the air into the capillary tubes of the stone, carrying with it the atmospheric impurity, and so continue the decay by a constant alteration of atmospheric pressure. That was a better explanation of the decay in stone than he had ever heard before. We were building to-day with Portland stone, which was considered to be the best possible stone to use, and it was interesting to record as an example of how that stone depreciated under pollution of the atmosphere that, in connexion with one of our great buildings, in 14 years the surface of the Portland stone had actually gone back over one-eighth of an inch. He trembled to think what it would be like in 400 years time. No building or monument seemed to be safe from the attack of atmospheric pollution, either in towns or in the country.

The author had said that he was not prepared to talk about cures or solutions, but personally he thought he ought to be pressed to do so. He ought to be told, "You know so much about the cause of the disease, and its aspects, and its physical manifestations, that surely you can tell us of a panacea." He himself had tried panaceas. He had tried to get the occupants of the houses of great housing schemes to accept gas and to eliminate the raw coal fire, but there was an inveterate hostility to gas on the part of the inhabitants, except for cooking, and, in his opinion, unless people were going to get gas at a third of the cost of coal it was hopeless to attempt to make them use gas. With regard to electricity, it seemed quite impossible to persuade people to eliminate the domestic grate and to accept electric heaters. When he had been in Switzerland he had been astonished to see in that country, which was remarkable for cheap electric power, that people were using ordinary raw coal for firing their boilers. Therefore it seemed as if electric power was not a solution. He thought the author should be pressed to say what was his solution. Personally, he would suggest that it ought to be a new form of heat, but he could not state how that should be obtained. He thought the public generally was prepared to take a definite posture on the whole problem if scientists like Dr. Owens and Sir Napier Shaw would give them a lead.

There were innumerable questions which he would like to ask, but there was no time at present. For instance, he would have liked to have asked Dr. Owens how, if a very good method of low temperature carbonisation was evolved by which a very good low temperature fuel could be obtained, he would eliminate sulphur from that fuel?

Dr. Arthur W. Hill, F.R.S. (Director, Royal Botanic Gardens, Kew) said, as custodian of the Royal Botanic Gardens, Kew, he had been particularly interested in what the author had said. He had brought with him a collection of evergreen shrubs and a pane of glass from one of the greenhouses at Kew in order to show the appalling effect which the recent fogs had had on the vegetation there. For instance, so bad was the effect of the sooty deposit on the conifers at Kew that the Forestry Commission had given an area of land at Bedgebury, near Tunbridge Wells, for the purpose of forming a National Collection of conifers where they would be comparatively free from the effects of the London smoke. It was not only the visible soot and filthy smoke, but it was the injurious effects of the sulphurous fumes which did so very much damage. Just before the recent very bad fogs there had been a magnificent collection of orchid flowers at Kew, for which any big shop would have paid £100, but with sulphur penetrating everywhere, in about half an hour the whole of those orchid flowers had been entirely ruined. The same disastrous effects occurred with begonias and other plants with delicate leaves or flower All plants were badly affected by foggy days. Therefore, speaking of vegetation, as Sir Frank Baines had spoken of buildings, anything which could be done to eliminate or mitigate the evil effect of smoke would be of extraordinary value.

He had been interested to see on the screen a particular chimney just opposite Kew in Brentford, against which he had been agitating for some time. One of his predecessors had had to take action in regard to another chimney in Brentford which had been belching out smoke to an enormous extent, and the owners of that chimney had been compelled to take measures to prevent the emission of that smoke. A year afterward a representative of the firm called at Kew and had said that he really had to thank the Kew authorities for the action they had taken, because his firm had found that in emitting that smoke they had been losing many valuable products up the chimney and that owing to the Kew authorities' action they had saved many thousands of pounds. He only hoped the owners of the chimney to which he was at present referring could be compelled to adopt similar measures. He thought, however, that it was the domestic chimney which was the main cause of the trouble.

Colonel Sir Arthur Holbrook, K.B.E., M.P., remarked that after hearing how the nation's buildings and monuments were being destroyed in the rapid way which had been described, and how plants died in an hour under an accumulation of smoke, he felt nervous as to what was going to happen to himself in the future.

He could not help thinking that one cure for the evil—which ought not to be beyond the engineering skill of our great scientists—was to invent some means of consuming smoke in the chimney itself. If, as Dr. Hill had said, the Brentford people had found that the deposits which they had saved by keeping the smoke inside the chimney were worth thousands of pounds, surely the ordinary householder might follow the same practice and thus be able to make enough out of his chimney to pay for his taxes.

He was glad to find that lectures on the subject were being continued. It was important that people should have their eyes opened to the danger of coal fogs in London. The public should make up its mind to get rid of coal fires as soon as possible. That was the solution. He remembered reading with great alarm a short time ago that during a big smoke fog in London, for every cubic inch of air which a pedestrian breathed he swallowed 340 thousand particles of soot. That was a most alarming statement, and probably answered the question which the author had asked, namely, where the smoke went to! Those who were interested in the subject should, he thought, band together in order to educate their friends and the public generally on the matter. Reforms could only be effected by public opinion, and it was for those interested in the subject to create that public opinion and to do all they could to get their friends to realise that, to a large extent, the people themselves were to blame for the evil.

MR. F. W. GOODENOUGH (Gas Light and Coke Company) said he thought he could state one fact which might to some extent reassure Sir Frank Baines, who had said that the public would not use gas. Outside the Government Offices, who were the worst offenders in the use of coal fires, he could state that in ever-increasing numbers the public were using gas fires as well as gas cookers and water-heaters. The last four years had shown the following figures in regard to the increase of gas appliances amongst customers, other than those using penny-in-the-slot meters: Four years ago 23,000 increase in the year; the next year 43,000; the next year 44,000, and last year 67,000. He could take Sir Frank Baines to thousands of homes in London to-day where there was not a single coal fire being burned. It was the absence of domestic servants which was helping to solve the domestic smoke problem, because gas had the advantage of involving no labour in dealing with it. That fact was helping towards a solution of the evil, even more than the public opinion created by the advocates of smoke abatement. He thought the author underestimated the proportion of smoke due to industrial causes from his charts; it was not accurate to deduct from the week day curve of solid particles the Sunday curve, and regard the difference as the amount due to the industrial output in the week, because there was considerably more cooking done on Sunday than on any other day of the week in the morning. That was borne o by the fact that the maximum hourly load on the gas works throughout the country was to be found between 11 and 1 on Sunday.

DR. MARGARET FISHENDEN (Fuel Research Board, Department of Scientific and Industrial Research) thought the author had made it quite clear that the primary cause of smoke was the non-industrial, including the domestic, fire. It did not matter exactly what the proportion was, but if the domestic fire was responsible for anything like twice as much smoke as the industrial chimney, it was a matter for serious consideration. She did not agree that the preference for the coal fire was entirely a sentimental one; she thought it was mainly a matter of habit. The alternatives to raw coal were either gas, electricity or smokeless solid fuels. Electricity for the present was ruled out (except in special cases, or as a luxury), not only because it was very high in cost to the consumer, but also, in her opinion, because it was wasteful in the matter of supplies; it took too much coal to produce electricity for it to be a really economic solution. What the future might bring she did not know. Gas was in a very much better position. From the point of view of national fuel conservation there was a very good case to be made out for gas. It was extremely convenient, and for intermittent heating it was as cheap as coal. In some cases, if the cost of labour were taken into consideration, it was cheaper than coal, but the fact remained that for continuous heating coal was cheaper. Then one came to the question of coke. There had been many attempts made recently to produce low-temperature cokes, and she thought it was probably correct to say that the problem, from the technical point of view, was solved, but from the economic point of view it was not solved; that was to say, the satisfactory production of those smokeless cokes on a commercial scale was still uncertain. She made bold to say that any one who had seen a fire composed of good low-temperature coke would never want to go back to a coal fire again. It was an almost perfect fuel for nearly every domestic use, and if used in conjunction with gas for cooking, smokeless houses would be the result. As far as cost was concerned, she thought smokeless coke was worth a good deal more than the coal, because it gave more heat per weight. While the problem of smokeless cokes was being further investigated, she thought a very great deal might be done by using more gas coke, but she would put forward a plea for supplying gas coke with less moisture than it usually contained at present. One of the reasons why gas coke was difficult to ignite was because it contained so much moisture.

Dr. Owens, in reply, said he had rather expected to be criticised for not having suggested remedies for the evil, but one could not put everything one desired into a paper. His paper was already much too long. It was not that the question of remedies had not had his consideration, but that he had definitely come to the conclusion that the remedy for the evil was known if only people were prepared to pay for it. For instance, as Mrs. Fishenden had pointed out, low-temperature coke was a remedy, but people were not prepared to pay for it. Gas would solve the difficulty. It was a little more costly probably for continuous heating, but for intermittent heating it was cheaper, and it was cheaper for cooking. Then there was the use of coke. That would prevent smoke. There was anthracite, and there were a great many other things which would help to solve the difficulty. The thing to do was to influence public opinion—to make people have the desire to remedy the evil, and then a remedy would be found, because there were plenty of people who knew how to handle the problem. He did not agree with Mr. Goodenough's criticism of his curves. It was true there was a little more cooking on Sunday, but the *quid pro quo* was that there were a great many less office fires on Sunday. He had considered that point very carefully, and he had put the cooking against the office fires.

On the motion of the Chairman, a hearty vote of thanks was accorded to Dr. Owens for his paper, and the meeting terminated.

OBITUARY.

Lord Curzon of Kedleston, K.G.—By the widely and deeply lamented death of the Marquess Curzon of Kedleston, in London on March 20th, after a fortnight's illness, the nation and the Empire lose one of their foremost statesmen and the

Society an old friend and supporter. Born sixty-six years ago at the Derbyshire family seat, Kedleston, he was the eldest son of the Rev. Alfred Nathaniel Holden Curzon, fourth Baron Scarsdale, and his wife Blanche, daughter of Joseph Pocklington Senhouse, of Netherall, Cumberland, and sister-in-law of the late Sir Wilfrid Lawson, to whose well-known views on temperance reform Lord Curzon had at any rate in early life a leaning. From Eton he passed to Balliol College, Oxford, and, to quote his own words, sat at the feet of Dr. Jowett, by whom he was "always regarded as a man certain to distinguish himself."

His eminent public career began in 1885 when he became Assistant Private Secretary to the great man he succeeded later as Secretary for Foreign Affairs, the third Marquess of Salisbury, and fought his way into Parliament as member for Southport. That seat he continued to hold till 1898, when having proved his capacity as a politician and minister he was chosen to succeed the ninth Earl of Elgin as Viceroy and Governor-General of India. To add greater dignity to his new position an Irish peerage, without a seat in the Upper House, was conferred upon him apparently with his own acquiescence as he did not wish then, by accepting a peerage of the United Kingdom, to be deprived of the power of returning to the House of Commons. With the exception of Dalhousie, no man at Lord Curzon's age had attained what has been called the highest position under the Crown. Lord Curzon was sworn in at Calcutta some days before his 40th birthday. Dalhousie was born on the 22nd of April, 1812, and took up his duties at Calcutta in January, 1848. In the interval between the completion of Lord Curzon's first term as Viceroy and his reappointment he came to England for a holiday. No effort was spared to show him how much his services in India were appreciated here. In the first place King Edward made him Warden of the Cinque Ports and the Corporation of London bestowed the Freedom of the City upon him in the presence of a large and brilliant gathering.

After returning from India upon his resignation of the Viceroyalty he finally abandoned the idea of ever resuming Parliamentary life in the House of Commons and entered the House of Lords as an Irish representative peer. In 1911 he was created Earl Curzon of Kedleston with the minor titles of Baron Ravensdale and Viscount Scarsdale. He was one of the Opposition leaders who joined Mr. Asquith on May, 1915, taking the office of Lord Privy Seal. He was included in Mr. Lloyd George's Government on December, 1916, as Lord President of the Council, Leader of the House of Lords and member of the War Cabinet. When the Coalition Government fell he was in office as Foreign Secretary, having succeeded Mr. Balfour in October, 1919. He held the same position in the Government of Mr. Bonar Law and Mr. Baldwin, but when Mr. Ramsay Macdonald and his friends went out of office, and the Conservatives returned to power he was assigned the posts of Lord President of the Council and Leader of the House of Lords. The decision not to restore him to the Foreign Office caused him "great disappointment," but as the *Times* remarks he accepted it with good grace and ably represented his Government in the Upper House. Subsequently the objections successfully urged by political associates to his following Mr. Bonar Law, as Prime Minister, was a source of renewed blighted hope, but, as the *Times* observes, it was not the least remarkable feature of his character that, with all that air of arrogance that impressed the world he could again and again accept with dignity rebuffs, disappointments, and the sudden overriding of his plans and dearest desires. One long and intimately associated with him says that when all the facts are known Lord Curzon's gesture of self-effacement in the Coalition and later will "be counted as one of the noblest acts of his life."

The coveted Garter came to him in 1916 and another rare honour, the Royal

Victoria Chain, in 1903. He had been Chancellor of Oxford University since 1907. His Marquessate, Earldom and Irish barony cease to exist with his death, but the Viscountcy descends to a nephew and the Barony of Riversdale to his eldest daughter.

Lord Curzon's long connexion with the Royal Society of Arts dated from 1895, when he was elected a Life Member and he was a Member both of the Council and the Committee of the Indian Section at the time of his death. Between 1894 and 1923 he presided at no fewer than eight meetings of the Indian Section. He once said he thought that the Fellows must be tired by seeing him so frequently in the chair, but the crowded state of the Lecture Hall whenever it was announced that he would speak afforded proof to the contrary. On the occasion of his presiding in 1907 at Sir Frederic Lely's lecture on " The Practical Side of Famine in India"—it was not very long after he lost his first wife—he told the audience that although at the time he was taking no part in public affairs he could not resist the invitation which he regarded almost as a command to be present and introduce the reader of the paper. Sir Frederic Lely, he declared, was one of the most eminent civilians who had served the Government of India in recent years, distinguished both by the eminence of the posts he had filled and by his notorious sympathy for the people. In commenting later in the evening on the paper, which he observed was of " a somewhat unusual character even in the annals of the Society," Lord Curzon bore testimony, from his own experience of the terrible visitation, to the fidelity of the picture drawn by the lecturer. Lord Curzon's last appearance at a meeting of the Society was in June, 1923, when he presided at Sir John Marshall's Birdwood Memorial Lecture on " The Influence of Race in Early Indian Art." On that occasion Lord Askwith, speaking as the then Chairman of the Council, said it might be that Lord Curzon's Viceroyalty, which when the history of India was written must ever remain as one of the most remarkable features of recent times, would be heralded as the beginning of a new movement in Indian art, partly by the preservation that he accorded to its ancient monuments, and that his influence might have a more far-reaching character than could even at present be dreamt of. The Queen Victoria Memorial Hall at Calcutta is said to be entirely due to him.

Opinions may differ as to Lord Curzon's later record in home politics, but probably few will disagree with the view that his best and most enduring work was done during his Viceroyalty of India. " He was," it has been said, " a great Viceroy—perhaps the last of the great Viceroys of the old school." Many who had opportunities of judging will, we think, be disposed to concur with the following passage from a leading article in the *Times* of Saturday :—"The friends and colleagues who succeeded in penetrating the barriers of his reserve knew that there was more behind them than the many-sided industry, the finished writing and speaking, the pomp and circumstance of Lord Curzon's official *facade*. He had a deep sense of public service and an astonishing courage in fulfilling it under a strain of constant suffering which would have driven most men into retirement."

The Society was represented at the funeral service in Westminster Abbey, on Wednesday, by Sir Edward A. Gait, Member of the Council and Chairman of the Indian Section Committee.

Sir Marshall Reid.—Sir Marshall Frederick Reid, C.I.E., died on March 20th at his residence, Woodcote Lodge, Epsom, in his sixty-first year. Son of the late Mr. Daniel Reid, of Glasgow, he was educated in Scotland at Loretto School, and went to India to join the staff of the Bombay Company, Limited, of which he eventually became the managing director. He was a member of the Bombay Legislative Council from 1912 to 1913 and of the Imperial Legislative Council of India from 1914 to 1915. During the latter period he occupied the position of Chairman of the Bombay Chamber of Commerce, and was also a director of the local Presidency Bank. Upon returning to this country Sir Marshall was invited by the then Secretary of State for India, Mr. Austen Chamberlain, to fill a seat on the Council of India, and he retained that position until the end of 1919, when he resigned to devote himself entirely to his business affairs. While still on the India Council he served as a member of the Committee on Indian Exchange and Currency appointed in 1910 under the presidency of Sir Henry Babington Smith. Subsequently he was one of the delegates for India at the financial congress held in Brussels by the League of Nations. In the City of London he was well known and respected as a partner of Messrs. Wyer and Hawke, East India merchants, and as a director of the Anglo-Egyptian Bank. Since 1917 Sir Marshall had been a life fellow of the Royal Society of Arts, in whose Indian Section he always took considerable interest. He was made a companion of the Order of the Indian Empire in 1902 and knighted in 1916.

NOTES ON BOOKS.

Science and Labour. The principal speeches and papers given at the Conference on Science and Labour held in London on May 30th and 31st, 1924. Edited by Thomas Lloyd Humberstone, with a preface by Lord Askwith. London: E. Benn, Ltd. 7*s.* 6*d.* cloth or 6*s.* in paper covers.

The peculiar value of this book, not only to the mature economist, but also to the most cursory student, rests in the fact that many views are presented, and, indeed, well presented by men of eminence.

Mr. Sidney Webb hinted that the laboratory expert may in some cases go too far unless he is nursed or watched or guarded by a statesman. Sir Richard Glazebrook, the motive spirit of the National Physical Laboratory, and Mr. Richard B. Pilcher, the protagonist of the Institute of Chemistry, rose in reply each in his own way.

So all through, view against view, a tolerant consideration of both sides; toleration of a kind likely to lead to progress in the best sense of the term.

And the result? That excess must be avoided, that all parties should unite in finding the middle way, all extremes being bad.

Every one interested in economics, in science, in technics, and in true progress should obtain this volume. But something is needed; the book must be carefully studied till the real meanings of the speeches and the final balances of expediency dawn on the reader.

The Constituents of Coal Tar. By Percy Edwin Spielmann. London: Longmans, Green and Co. 12*s.* 6*d.* net.

This volume of 220+XII pages is just what a laboratory book should be, the admirable index guiding the student when he has occasion to use the mass of detail regarding the numerous constituents of coal tar.

As an example of laborious thoroughness we may refer to p. 31, where benzene is considered as the first among monocyclic hydrocarbons; freezing points, boiling points and specific gravities being given or tabulated as influenced by ordinary or usual conditions. Separation and purification are explained in full detail, freezing out or crystallisation being a leading feature of the up-to-date aspect; also the relative efficiency of drying agents being quantitatively tabulated from sodium sulphate to phosphorus pentoxide. It is noted that plaster of Paris is a useful drying agent, and this may give a hint to those having occasion to dehydrate oils, alcohols or ketones, and also to those who use drying cupboards.

Impurities of benzene, their detection and elimination, are studied with quite remarkable fulness, and we assume that much of the important work which Dr. Spielmann did for us in the war time is embodied in this part of the book. On p. 37 it is suggested that "absolutely pure benzene," by reason of the constancy of its freezing point, may serve to give a fixed position in thermometry. Other questions in thermometry seem to arise out of the work under notice, as (p. viii.) the question of uncertainty when no scale is indicated; for example, in many chemical writings degree means a degree as defined by Celsius, and in many meteorological writings or, perhaps, most British journalistic writings, the term "degree" means a degree as defined by Fahrenheit. Meteorologists have found it inconvenient to use the scale of Celsius, because their readings would then be so frequently changing the sign (plus and minus) in one and the same sequence of observations. Chemists, owing to increased work at temperatures between the two usual zeros, are now almost in the position which has so long affected meteorologists. Indeed, we notice that on p. 33, and 15 other pages of Dr. Spielmann's book, there are examples which serve to illustrate the increasing inconvenience of a high thermometric zero to the chemist and to readers of chemical books. Hence the proposal of the late Dr. Murray, of Edinburgh, for writing the advantages of the two usual scales seems to take a new interest. On the Murray (or Millegrade) scale the zero is the freezing point of mercury and the boiling point of mercury is 1,000 degrees. Dr. Murray mentions 99° and 347° as the ice and steam graduation positions for his thermometer; the interspace being marked off into 248, so that the scale would almost proclaim itself in ordinary cases, without the use of an indicating M.

Dr. Spielmann dedicates his work to Tilden, his first teacher in chemistry, and what he suggests in the preface as to extended research in Great Britain deserves attention. In sum, Spielmann has given us a monograph on the aromatic series worthy of Kekulé himself, and Messrs. Longmans may justly feel pride in adding this work to their series of "Monographs on Industrial Chemistry."

MEETINGS OF THE SOCIETY TO APRIL 29.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock, unless otherwise announced:—

APRIL 1.—WILLIAM NUNN, late Adviser to the Siamese Government on Customs and Excise, "Siam: its Progress and Possibilities." BYRON BRENAN, C.M.G., will preside.

APRIL 22.—CEDRIC CHIVERS, "Bookbinding." J. M. DENT will preside.

APRIL 29.—LIEUT.-COLONEL ANDREW BALFOUR, C.B., C.M.G., M.D. (Edin.), B.Sc., D.P.H., F.R.C.P.E., "The Trend of Modern Hygiene."

DOMINIONS AND COLONIES AND INDIAN SECTIONS. (JOINT MEETING.)

THURSDAY, APRIL 16 (4.30 p.m.)—LORD STEVENSON, G.C.M.G., "The British Empire Exhibition." SIR CHARLES CAMPBELL MCLEOD, Bt., will preside.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

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Monday, March 30..Shakespeare Reading Society, at the Royal Society of Arts, John Street, Adelphi, W.C. 7.30 p.m. Recitation Competition by Pupils of the L.C.C. Schools.

Farmers' Club, at the Surveyors' Institution, 12, Great George Street, S.W. 4 p.m. Sir John M'Fadyean, "Preventable Diseases in Farm Live Stock."

British Architects, Royal Institute of, 9, Conduit Street, W. 8 p.m. Mr. A. Beresford Pite, "The Architectural Treatment of Ferro-Concrete."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 7 p.m. (Graduates' Section). Discussion on "Road versus Rail Transport."

Swiney Lecture, King's College, Strand, W.C. 5.30 p.m. Dr. W. T. Gordon, "The Geological History of Plants." (Lecture IX.)

Actuaries, Institute of, Staple Inn Hall, Holborn, W.C. 5 p.m. Mr. R. D. Anderson, "Apportionment of a Trust Fund Between Life Tenant and Reversioner."

Tuesday, March 31..Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. A. Pereira, "Personal Reminiscences of the Mount Everest Expedition, 1924."

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. A. S. Eddington, "The Internal Constitution of the Stars." (Lecture II.)

Alpine Club, 23, Savile Row, W. 8.30 p.m. Mr. L. A. Ellwood, "The Transylvanian Alps and the High Tatra."

Wednesday, April 1..Naval Architects, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 11 a.m. Annual Conference. (1) Address by the President (the Duke of Northumberland). (2) Sir John H. Biles, "Relative Commercial Efficiency of Internal Combustion and Steam Engines for High Speed Passenger Vessels." (3) Prof. F. P. Purvis, "Japan's Contribution to Naval Architecture." (4) Mr. G. H. Hoffmann, "Analysis of Prof. Sir John H. Biles's Paper on H.M.S. 'Wolf' Experiments."

United Service Institution, Whitehall, S.W. 3 p.m. Major-General W. M. St. G. Kirke, "Modern Finland."

Historical Society, 22, Russell Square, W.C. Miss E. J. Davis, "The Dissolution of the Priory of Holy Trinity, Aldgate (1552), and its Historical Significance."

Entomological Society, 41, Queen's Gate, S.W. 8 p.m.

Swiney Lecture, King's College, Strand, W.C. 5.30 p.m. Dr. W. T. Gordon, "The Geological History of Plants." (Lecture X.)

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. (Wireless Section.) Major A. G. Lee and Mr. A. J. Gill, "The Leafield Coupled Arc."

(S. Midland Section), at the University, Edmund Street, Birmingham. 7 p.m. Colonel T. F. Purves, "The Post Office and Automatic Telephones."

Public Analysts, Society of, at the Chemical Society, Burlington House, Piccadilly, W. 8 p.m. (1) Mr. W. Dickson, "Quantitative Estimation of Cotton, Linen and Wood Fibres in Paper Pulp." (2) Dr. J. C. Drummond, "Vitamins in Bread." (3) Mr. G. D. Elsdon, "Proposed Standards for Lemon Cheese." (4) Discussion on the "Desirability of Standards for Food Products." (5) Dr. P. H. Prausnitz, "Laboratory Filters made of Sintered Glass and their various Uses."

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. (Students' Meeting.)

Thursday, April 2..Naval Architects, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 11 a.m. Conference continued. (1) Admiral D. W. Taylor, "Wake Propeller Coefficients." (2) Mr. W. G. A. Perring, "Form Effects and Form Resistance of Ships." (3) Mr. W. Pollock, "A Suggested Method of Increasing the Efficiency of the Screw Propeller."

3 p.m. (1) Prof. C. E. Inglis "Stresses in Rectangular Plates Clamped at their Edges and Loaded with a Uniformly Distributed Pressure. (2) Mr. G. Vedeler, "Notes on the Rolling of Ships." (3 Mr. H. J. R. Biles, "Model Experiments with Anti-Rolling Tanks."

8 p.m. Second Report of the Marine Oil Engine Trials Committee.

Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p.m.

Victoria and Albert Museum, South Kensington, S.W. 6 p.m. Prof. W. Rothenstein, "Indian Paintings and Sculpture."

London County Council, at the Geffrye Museum, Kingsland Road, E. 7.30 p.m. Mr. J. C. Rogers, "The Materials used and the old Methods of Construction in Relation to Design in Furniture."

Mechanical Engineers, Institution of, (N. Western Branch), at the Engineers' Club, Manchester. 7 p.m. Mr. E. A. Eborall, "Swiss Federal Railway Electrification."

Child Study Society, 90, Buckingham Palace Road, S.W. 6 p.m. Mr. Ben Greet, "Plays for Children."

Royal Institution, Albemarle Street, W. 5.15 p.m. Mr. T. T. Baker, "Chemical and Physical Effects of Light" (Lecture II.)

Chemical Society, Burlington House, Piccadilly, W. 8 p.m. (1) Messrs. C. S. Gibson and J. L. Simonsen, "The Formation of *d*-2:2:4-trimethylcyclohexan-3-one-1-carboxylic acid from *d*-camphorquinone." (2) Mr. W. H. Gray, "Aromatic Esters of Acylecgonines."

Linnean Society, Burlington House, Piccadilly, W. 5 p.m. (1) Mr. W. C. F. Newton, "The Cytology of the genus *Tulipa*." (2) Mr. W. R. B. Oliver, "Bio-geographical Relations of the New Zealand Region."

Friday, April 3..Naval Architects, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 11 a.m. Conference continued. (1) Mr. E. W. Blocksidge, "Tonnage Legislation and its Application to the Measurement of Ships." (2) Mr. W. G. Cleghorn, "Influence of Trading Conditions on the Design of Intermediate Passenger Vessels." (3) Mr. C. F. Holt, "Stability and Seaworthiness."

3 p.m. Mr. A. H. Haver and Dr. E. V. Telfer, "The Propulsive Performance of the Corrugated Ship."

London County Council, at the Royal Society of Arts, John Street, Adelphi, W.C. 6 p.m. Lecture on "Modern Movements in Education."

Philological Society, University College, Gower Street, W.C. 5.30 p.m. Prof. W. A. Craigie, "Dictionary Evening."

Engineers, Junior Institution of, 39, Victoria Street, S.W. 7.30 p.m. Mr. G. W. Tookey, "Engineering Contracts."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 7 p.m. (Informal Meeting.) Discussion on "Modern Developments of Gas Production."

(Yorkshire Branch), at the Philosophical Hall, Park Row, Leeds, 7.30 p.m. Mr. H. W. Swift, "The Accurate Measurement of Liquid Flow."

(Graduates' Section, Midland Branch), at the Chamber of Commerce, New Street, Birmingham. 7.30 p.m. Mr. C. H. B. Worrall, "Engineering Costing and the Factors Concerned."

Auctioneers' and Estate Agents' Institute, 29, Lincoln's Inn Fields, W.C. 7.30 p.m. Mr. H. M. Rogers, "The Making of a Connoisseur," Part IV.—"English Porcelain."

Geologists' Association, at the University College, Gower Street, W.C. 7.30 p.m. (1) Prof. W. T. Gordon, "The Geology of the Yellowstone Park District, U.S.A." (2) Mr. G. W. Young, "Science Notes on the Yellowstone Park and the Shoshone Valley."

Royal Institution, Albemarle Street, W. 9 p.m. Sir Daniel Hall, "The Productivity of English Land."

Saturday, April 4..Royal Institution, Albemarle Street, W. 3 p.m. Prof. J. H. Ashworth, "The Nervous System of Marine Annelids." (Lecture II.)

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FRIDAY, APRIL 3, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

SIXTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 25th, 1925. Mr. H. D. SEARLES-WOOD, F.R.I.B.A., in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Dodd, Edgar, Compton, Wolverhampton.
Nicholas, George Augustus, London.
Phillips, Stanley Tysoe, London.
Satchell, Octavius, London.
Varley, Lieut.-Commander Cromwell H., R.N. (ret.), D.S.C., London.
Ward, Melville Seth, F.R.I.B.A., London.

The following candidates were duly elected Fellows of the Society :—

Brown, Percival, Barnsley, Yorks.
Elliott, William Ebenezer, Wallasey, Cheshire.
Goodman, William Henry, London.
Harding, Walter, Noctorum, Cheshire.
Knowles, Professor Lilian C. A., Litt.D., London.
Morren, Percy John, St. Leonards-on-Sea, Sussex.
O'Conor, The Hon. Broughton B., M.L.C., Sydney, Australia.
Shastri, Hirananda, M.A., Ootacamund, India.
Strang, Robert Winning, Kilmacolm, Renfrewshire.

A paper on " Wallpapers " was read by Mr. HENRY G. DOWLING, Chief Decorative Adviser, Messrs. John Line & Sons.

The paper and discussion will be published in a subsequent number of the *Journal.*

TEN-VOLUME INDEX TO "JOURNAL."

The amalgamated Index to the *Journal of the Royal Society of Arts* for Vols. LXI-LXX (1912-1922) is now ready, and can be obtained free by Fellows of the Society on application to the Secretary, Royal Society of Arts, John Street, Adelphi, London, W.C. The price to non-Fellows is 2*s.* 6*d.*

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

TUESDAY, FEBRUARY 24TH, 1925.

MAJOR-GENERAL SIR ERNEST D. SWINTON, K.B.E., C.B., D.S.O., R.E., in the Chair.

THE CHAIRMAN, in introducing the reader of the paper, said the general subject of transport, always important throughout history, had become vitally so as the peoples of the world had grown less self-supporting and more interdependent for the supply of necessities, and even luxuries. Mr. Rudyard Kipling, who, with his great vision, had a knack of focussing public attention on the things that mattered, had said at a dinner of the Chamber of Shipping a few days previously : " When a nation is lost, the underlying cause of the collapse is always that she cannot handle her transport. Everything in life, from marriage to manslaughter, turns on the speed and cost at which men, things and thoughts can be shifted from one place to another. If you can tie up a nation's transport, you can take her off your books." Nowhere did the subject demand more earnest consideration than in Tropical Africa, where vast undeveloped regions of great potential resources remained to be opened up. With this the reader of the paper was well qualified to deal. Mr. Brackenbury had spent nine years surveying, prospecting and mining in the Gold Coast, the Transvaal and Swaziland, besides some time in the United States and Canada. For two years he was in charge of a mine in Africa, fifty miles from the nearest railway, and had to arrange for the carriage of hundreds of tons of material by ox transport. On the mechanical side, he had taken part in the development of the Diplock Pedrail, one of the first systems of flexible track propulsion. He was a member of the Sub-Committee of the Empire Cotton Growing Corporation, which was engaged in searching for the best method of carrying cotton from the plantations and ginning mills to the railway.

The paper read was :—

TRANSPORT IN TROPICAL AFRICA.

By R. H. BRACKENBURY.

Transport in Tropical Africa resolves itself from the European point of view largely into the questions of how, on the one hand, best to bring raw produce from the interior down to the Coast, so that it may be shipped to Europe ; and how, on the other hand, to send up the manufactured articles of Europe to the inland dweller.

The very large internal crosswise traffic of this country is practically unknown to Africa. In England the product of a blast furnace in Cumberland or Durham may go to a rolling mill in Sheffield, and from thence be distributed over the engineering shops to the South, until, perhaps, the iron from the ore returns to its original home in the form of a crane or a winding gear, after having been split up and brought together again through fifty or a hundred different processes, each one of which has meant transport from one works to another. There is nothing of this kind taking place in Tropical Africa to-day, for the factory system is an experience yet to be savoured by the natives of Africa and the method of distributing products, such as salt and potash, among themselves is hardly comparable to the internal transport of the more complex societies of Europe.

But perhaps the most striking characteristic of transport as we know it, in Tropical Africa, is the very large economic gap which comes between the primitive methods developed by the natives themselves and the highly specialised railway systems laid down by the governing European Powers. It is well known that the cost of railway transport per ton mile decreases as the quantities carried increase, whereas with the more primitive methods precisely the contrary phenomenon is observable: as the quantities increase, so also the cost of transport per unit increases too.

If developed in a graphical form on a chart, two curves, shewing respectively the cost per ton mile of gradually increasing quantities, the one in England, the other in Africa, would present a very marked divergence. In England, speaking generally, it is the carriage of the small quantity that shows the high cost per ton mile with a gradually reducing cost per ton mile as the quantities increase. That is to say, the cost curve on our diagram is a continually decreasing one. In Africa the cost of transport of comparatively small amounts is not excessive but, unfortunately, as production increases the cost per ton mile of transportation increases too.

The diagram will, therefore, shew the cost of African transport to be a rising curve becoming relatively steeper until it vanishes off into infinity, as the quantities to be carried run up into hundreds of tons per month, but dropping back again into manageable figures, only under very special conditions, or where the quantities involved are so large that it has become feasible to lay down a railway to deal with them.

To illustrate this point: 5 tons per month of produce from an estate 100 miles inland can be brought down to the coast by head porters or pack donkeys, or, best of all, if there is a waterway, by native canoes at rates per ton mile which are undoubtedly high but not prohibitive. Increase this 5 tons per month to 50 tons per month and your rates per ton mile will go up with a bound. Double this quantity and, if you are dependent on head carriage, you will have reached a point where, from the commercial point of view, conditions have become prohibitive. But a railway cannot be constructed to carry small quantities like these. And yet at present in many parts of Africa these are the only alternatives—head porters to carry tens of tons or a railway to carry thousands. Intermediate amounts—the kind of quantities which can most easily be produced in Africa—have to be left on the ground to rot because there are no means of transporting them.

A native will hardly carry, as a regular task, the recognised load of 60 lbs. more than 100 miles a week. What with cooks and headmen for each gang and other followers, it may be assumed that it requires 40 men to carry one ton of produce. To bring down 100 tons of produce a month over a distance of

100 miles will, therefore, absorb the useful work of 2,000 men, who would be far better engaged in agricultural, mining or pastoral pursuits than in this most necessary, but quite unproductive, employment. Moreover, apart from this economic objection, men are not available in these large numbers. We all look forward to a time when every fertile valley and plain throughout the 2½ million square miles of British Tropical Africa will send its grain, its cotton and its hides; every forest its lumber, its palm kernels and its rubber, to say nothing of its cocoa and coffee, its sisal and its hemp, and the thousand other products of this most prolific land, in little rivulets and streams of traffic amounting at the source to only a ton or two a month but swelling as they approach a railway, through the tens and twenties, to hundreds of tons a month until the totals of all these little feeders bring a volume to the arterial railways of many millions of tons of raw produce and minerals for the factories of Europe. Where are carriers to be found to deal with quantities like these?

Moreover, there are many other difficulties which make head carriage an extraordinarily unsatisfactory and uneconomic method of carrying transport. Many years ago, on the Gold Coast, before there were any railways in that country, I had to move a safe weighing 30 cwt. from a landing stage on the Ankobra river to a mining camp some 20 miles away. In those days we were very glad to have a safe on the property. for otherwise, as pay-day approached and the bags of silver for the natives' wages made their appearance, one found oneself under the necessity of sleeping with large and lumpy sacks of coin in one's bed. We could not put them under the bed as that was where we kept the cases of dynamite. However, in the nature of things, a safe is not readily divisible into 60 lb. head loads, and we had therefore to take it—the whole 1½ tons of it—in one piece by man power. It can be done—that I know because we did it—and as an experience it no doubt had its value, but the less said about the cost per ton mile the better. I very much doubt whether the safe would have held all the money that we had to pay the carriers for bringing it to us.

Then, again, of those who have been dependent at one time or another on head transport, who does not remember the bitterness of that almost intolerable experience of waiting until sufficient carriers have been collected to make a start? The morning visit to the local gaol to pick up any discharged criminals; the evening scour of the purlieus of the seaport town and the daily arguments with crimps, headmen, bar loafers and every type of idle good for nothing, until the minimum quota was made up? And having got your men together and made your start the daily toll of thefts, desertions, sickness—the damage to loads through accident, the loads lost crossing streams—the total inability to keep any sort of regular time table. In short, the inefficiency, the wastefulness, the extravagance of it. The only possible form in which head transport is tolerable from a business, as apart from a sporting point of view, is when a native is bringing his own produce down to some collecting centre, and even then the amount and distances are very limited.

It will no doubt be conceded without discussion that to carry regularly 1,000 tons per month from a point far inland to the coast by native transport methods, on carriers' heads, on pack donkeys, camels or even ox waggons, is quite an impracticable proposition from a commercial point of view. On the other hand, it is a very dubious venture to build a railway to carry quantities so small. This point can, perhaps, best be illustrated in the following way.

Light railways in Tropical Africa can hardly be built for less than £5,000 per mile. I do not suppose that this statement will be questioned, but, by way of illustration, I will quote two figures. The railways of Nigeria are one of the largest systems in Equatorial Africa with their 1,100 odd miles of open line. It is well known to engineers that great economy and efficiency was shewn in their construction, and yet in the administrative report for 1924 the capital cost is given as £11,000 per open mile. Again, Colonel Hammond, R.E., is the present authority selected by the Colonial Office to report on the administration and finance of Tropical African railways. In his report on the Gold Coast Government Railways he criticises an estimate of £17,000 per mile for new construction, and considers that £13,000 per mile is a fair figure. Within the limits of a paper like this, it is impossible to discuss the comparative merits of railways, light railways, narrow gauge railways, tramways, mono rails, road rails and the like. I must confine myself to expressing what I believe is the average considered judgment of competent engineers familiar with these matters.

Where conditions necessitate the construction of some permanent way and yet do not admit, in the first instance, of the high cost of heavy main line construction, it is found, on the whole, to be more economical in the long run, and, generally speaking, better practice to build a light railway of full gauge rather than a line of a narrower gauge.

However, coming back to the original point, it will be agreed that in the light of past experience, £5,000 per mile is not an exaggerated estimate of the average cost of a Tropical African light railway. Nor will 6% per annum be considered an excessive remuneration to the lenders of the capital. Provision has also to be made for the maintenance and replacement of the rails, sleepers, earthworks, etc. 4% per annum for these renewals give an average life of 25 years, which is fully as long as can be expected under tropical conditions. We find, therefore, that £500 per annum per mile is a very moderate estimate of the interest charge on the capital expenditure of a railway in Tropical Africa. Now this interest charge is not a heavy burden per ton mile, provided it can be divided over a sufficiently large tonnage, but it becomes formidable when the volume is reduced within the limits mentioned before. If, for example, the total amount of traffic over the whole length of the railway averaged only 10,000 tons in the year, then, it will be seen, this interest on capital is a first charge of 1/- per ton mile. Halve the tonnage and the charge is multiplied by two. Reduce the quantity still further to, say, 200 tons per month, then this charge amounts to no less than 4s. per ton mile. And it will be understood that this figure includes nothing for the operating cost of the railway, which is no small amount in Tropical Africa. There may be military or strategic reasons which compel such construction, but that opens up rather a different line of argument and thought into which at the moment I do not propose to enter. Speaking from a business point of view, and disregarding special circumstances, I believe that it is not an economic or commercial proposition to build a railway in Tropical Africa to carry less than an average of 1,000 tons of goods or produce per month over its whole length. In any case, while there may be room to argue over the exact figure, which indeed will vary in each individual case, there is no escape from the main proposition that below a certain tonnage a railway is not an economic possibility.

Thus one sees what a gap there is between the maximum practical limits of head porterage and the minimum economic possibilities of railway transport, and here I do believe we have our hand on the very heart of the explanation of the delay in the full development of the almost limitless resources of Tropical Africa. Let us now consider what means of transport are available to bridge or rather to fill in this gap.

An improvement on head transport is provided by pack donkeys carrying a load of 100-120 lbs., and while it is obvious that the solution of African transport is not to be found here, nevertheless the possibilities of this method of carrying native produce might well be more fully exploited. In the Gambia a considerable amount of produce is brought to the market by this means, and there seems to be no logical reason why this excellent example should not be adopted and developed in other parts of Equatorial Africa. In the Gambia the donkeys are bred and owned by the natives themselves, and a system has grown up under which it has become the custom for the natives to deliver their goods to the trader at his selected point—a wharf on the river—instead of the trader having to fetch the produce from the village market. This system throws the earlier short distance transport on to the producer, who here, as elsewhere in Tropical Africa, can do this service more economically than any one else. Moreover, it widens the native's horizon ; it increases the scope of his activities and therefore of his requirements. As his needs expand he will increase his production proportionately.

That Tropical African Bible—the " Dual Mandate "—to which we all have to refer to check our facts and to draw fresh inspiration, gives the cost of head transport, when wages are ninepence a day, at 3s. per ton mile. Another way of putting it is that the cost per ton mile is approximately four times the daily wage. The cost of pack transport is stated to be " rather less." In considering these figures, however, there are two important qualifications to be borne in mind. The one, which affects both head and pack transport, is the inevitable rocketing of wages as the quantities to be carried become important, so that the possibilities of this form of transport are exhausted before really commercial figures are reached. The other qualification is the practical fact that pack transport is at present definitely excluded from those broad belts of territory which the tsetse fly rules as his demesne. Camels can carry a load of 480 lbs. and provide another form of pack transport which, under favourable circumstances, is no doubt more efficient than donkey transport, but outside his native desert the camel is useless. There are wide expanses of desert within the limits of the territory comprised in the term " Tropical Africa," but generally speaking the desert is unproductive, although, of course, large quantities of cotton are likely to come from the Sudan. Nevertheless I think that the camel is more likely to play a diminishing than an increasing part in the future development of transport in Tropical Africa.

A more efficient and altogether more adequate system is provided by the type of ox waggon used and developed in South Africa. These waggons, drawn by 16 oxen under the control of a competent white transport rider, will carry loads up to 5 tons or even more at a rate of 9d. or 1s. per ton mile over tracks the condition of which has to be seen to be believed. Were the climatic conditions but favourable these ox waggons might indeed go a long way towards solving the Tropical African problem. But, alas! there are but few parts of this territory where cattle are safe from the pests and diseases which play such havoc with oxen throughout Africa except on the high table-lands. A certain amount of ox waggon transport is to be found in Uganda among the South African settlers in that country, but it is too highly specialised a form of transport to be adopted by the African negro who, when left to his own devices, is not intelligent in his dealings with animals.

In any case the solution of the problem of the efficient transportation of Tropical African produce is not to be looked for in head porters, in pack animals, or even in ox or mule waggons. And this brings me to the consideration of mechanical transport other than railways.

At first sight it might be supposed that transport problems are much the same wherever they arise and that transport facilities in Equatorial Africa will develop along the same channels that experience has selected as the best under the competitive conditions of England, though naturally on a scale commensurate with the size of Africa. Protagonists of this view look forward to a time when the main trunk railways of Central Africa will radiate branches into all the more productive centres, which themselves will be interconnected by macadamised motor roads on the European model. In short, to those holding these ideas the problem is an economic one not calling for any specially new or different methods: provided sufficient funds can be begged, borrowed or otherwise acquired, the network of roads and railways will follow in due course. This is a simple and attractive picture, but is it true to life?

We have in British Tropical Africa an area of 2½ million square miles occupied by some 40 million inhabitants. In this country we have a somewhat larger population in an area of 120,000 square miles. Simple division shows that an equal density per square mile in Great Britain would be obtained by reducing our population from 47 millions to about 2 millions. Moreover, the amount of transport used in any country is probably closely proportional to the productive capacity of the inhabitants. Now the total trade of the 40 millions in British Tropical Africa is valued at 70 million pounds per annum, whereas the trade of Great Britain's 47 million inhabitants is some 2,000 million pounds per annum. The productivity and, therefore, ex hypothesi the transport requirements of an individual in this country is 24 times greater than the transport requirements of a Tropical African. Our 2 million inhabitants of Great Britain, therefore, would require some 24 times more transport than the same number of natives inhabiting the same area in Tropical Africa. In order to get a true comparison our already attenuated population of 2 millions must be still further divided by 24. It is stimulating to the imagination to reflect on the condition of our roads and railways if their construction and maintenance were dependent on the fees paid for transportation by a total population numbering some 84,000 souls, men, women, and children, distributed throughout the whole length and breadth of England, Scotland, Wales and Ireland. Yet that is approximately the position of Africa to-day, though even then the worst has not been told, because no allowance has been made for the climatic conditions under which our hypothetical macadamised roads have to be built and maintained. The luxuriant vegetation and the torrential rains of the tropics are deadly obstacles to the maintenance of a highway. Not only do I think that the construction of macadamised roads through and across Central Africa to carry heavy motor traffic is an impracticable dream, but I will go further and say that if main transport routes like our Watling Street or Dover Road could be laid across Africa from East to West and from North to South free, gratis and for nothing, with the sole proviso that they should be maintained up to our English standards by the districts and colonies which they traversed, even then they would prove to be not an asset but an intolerable liability.

It will be understood that I am not speaking now of the requirements of towns nor even of short stretches from one populous centre to another, but of main high roads to open up districts and territories which for economic or other reasons cannot be tapped by the railway. The future of Tropical African transport does not lie along macadamised roads. Railways, yes! Wherever a railway can be made to pay there, let one be put in. The main line railway running inland from the coast forms the backbone of the transport system and represents, under our modern conditions, the via militaris of those great colonisers, the Romans. Branch lines form the skeleton, and radiating out in every direction from each station and halt there will be tracks cleared through the jungle or flung across the deserts and prairies. No attempt should be made to provide foundations or a macadamised surface. Drains should be cut where necessary to prevent the track becoming a watercourse in the rains, and perhaps a sprinkling of gravel or crushed laterite might be given where such materials can be cheaply obtained, but real money is, in my opinion, better spent on building substantial bridges of stone or reinforced concrete over the streams and rivers than, as I think, wasted on an attempt, which can never be realised, to provide macadamised highways in Central Africa.

On the other hand, it is obviously quite impossible to run 4 ton or 6 ton petrol driven or steam driven lorries with their solid rubber tyred wheels on a regular service over roads which have neither foundations nor even a macadamised surface. This is so clearly recognised that laws have been passed in most of the tropical colonies absolutely forbidding the use of such vehicles. Speaking generally, motor transport used to be restricted to a maximum useful load of one ton on a vehicle which must be shod with pneumatic tyres. With the more general adoption of six-wheeled vehicles and balloon tyres the permissible capacity has in some cases been increased to two tons, and it is conceivable that by a multiplication of wheels and an enlargement of tyres, or by a more general use of trailers, considerably larger loads might eventually be carried on wheeled vehicles.

I will now shew you one or two slides dealing with the wheel.

The first illustration, for which I am indebted to the *Times*, shows a very common form of breakdown in the desert. The back wheels of the second car have sunk down in a soft patch and any attempt now to drive the car forward under its own power will only result in the wheels digging themselves in deeper. It is necessary, therefore, to hitch on to the front car, and in all probability when that is started up, and takes up the added strain, its two back wheels will dig themselves in also. Both cars will then have to be off loaded, extricated by hand, loaded up again, perhaps only to run into precisely the same situation again a little further on. I will now show you the two latest vehicles on wheels designed to meet this and other similar difficulties.

Slide No. 2 is a photograph of a 24 H.P. 2 ton six-wheel Albion lorry supplied to the Crown Agents for use on the Gold Coast,

We have here a vehicle where the total load is distributed over six wheels instead of four, which, making due allowance for the extra weight of the vehicle, gives an advantage of about 25 p.c. That is to say, the load on each wheel is substantially less than in a four-wheeled lorry of similar carrying capacity. Moreover, I draw your attention to the balloon tyres. The disintegrating effect on a road of a pneumatic tyre is very much less than that of a solid rubber tyre, more so indeed than their relative sizes would seem to warrant. The larger the tyre and the softer it is the less the damage.

Slide No. 3, Renault 6 twin-wheeler car for desert use.

This vehicle is the logical expression in a superlative degree of the underlying principle of the previous slide. Here we have the load distributed over twelve wheels, or at any rate six pairs of twin wheels, all of them shod with balloon low pressure tyres. Furthermore, both back axles are driven, which gives the very important advantage that the tendency of driving wheels to dig themselves in is distributed over eight wheels, that is, eight contacts with the ground, instead of two as in the conventional type. This is a strictly practical vehicle, which has achieved some remarkable results under desert conditions. On the other hand, the maintenance of twelve balloon tyres and inner tubes would be a heavy expense anywhere and particularly so in Tropical Africa, where manufactured rubber deteriorates so rapidly.

There are other types of wheeled vehicles that I might have shown. Traction engines developed with a view to gaining the theoretical advantages of very big or very broad wheels or, perhaps a combination of both. Then again the conventional type of petrol lorry but so arranged that all four wheels are driven instead of only the two rear wheels. This latter type has been very successful up to a point and is in fairly common use all over the world. But, however you wrestle with this problem, there is no escape from the fact that a wheel with its small contact, however lightly it may be laden and however soft may be the tyre, has a disintegrating effect on the surface it passes over.

Moreover, I would lay it down as a general proposition that the longer the journey the greater must be the load if the cost per ton mile is to be kept down. A 7 cwt. Ford delivery van may be very effective delivering goods in a town and its suburbs, but it is quite useless for the economic transport of produce over long distances. Even here round London it hardly pays to send market garden produce to Covent Garden in less than 4 and preferably 6 ton lorry loads. How much more does this consideration apply to loads of cotton, palm kernels, cocoa or ground nuts coming down in Central Africa to railhead or port over distances ranging up to 100 or more miles?

The crying need of Tropical Africa to-day is an adequate system of cheap transport capable of being expanded to meet any reasonable call made upon it by districts which are not served by a railway. Under the light of our present knowledge it would seem that this demand should be met by motor transport. If, however, it is agreed that the economic conditions of Equatorial Africa call rather for the heavier types of motor vehicles than the lighter, and, on the other hand, it is granted that it is impracticable, as I believe it to be impracticable, to provide in Africa the kind of cast iron roads which have been found essential for the heavy wheeled motor transport of Europe, then we appear to be on the horns of a dilemma from which there is no escape. However, modern engineering skill is not easily baffled, and if, for the moment, it is admitted that it is not possible in Africa to make the roads to suit the vehicles, there is every hope that we are now making vehicles to suit the roads, or rather the lack of them.

I am now about to describe that new type of mechanically propelled vehicle mounted on what are popularly known as caterpillar tracks. This method of transport received an enormous publicity and impulse on the appearance of the Tanks in 1916, but nevertheless the system was at that time no new one. The earliest records we have of attempts to oust the wheel from its supremacy as the most economical method of transporting heavy loads by land—a supremacy that had until then reigned unchallenged for many thousands of years—date back to the end of the eighteenth century when both in France and England efforts were made to find an alternative. Probably these eighteenth century inventors had only one clear objective in mind and that was to provide a vehicle which would combine the advantages of the wheel with those of its predecessor—the sledge— a vehicle which like a sledge could be drawn easily over soft and even boggy ground without getting mired and yet would roll along a road with no more effort than the equivalent mounted on wheels. Unfortunately, their endeavours, though crowned with success as far as the first part of this requirement was concerned, broke down completely on the second part and far from rolling easily at a touch it required a team of horses to pull the empty vehicle along a level road. At that time, of course, animals provided the only motive force available, so that any new type of waggon requiring a greater tractive effort to draw it than a wheeled waggon of similar capacity was damned from the start for commercial transport. Adam Smith, writing just about that time in 1770, has, as always, something instructive to say:—

" A broad-wheeled waggon attended by two men, and drawn by eight horses, in about six weeks time carries and brings back between London and Edinburgh near four ton weight of goods. Upon two hundred tons of goods, therefore, carried by the cheapest land-carriage from London to Edinburgh, there must be charged the maintenance of a hundred men for three weeks, and both the maintenance, and, what is nearly equal to the maintenance, the wear and tear of four hundred horses as well as of fifty great waggons."

It will readily be understood that the eighteenth century waggoner did not adopt with enthusiasm a vehicle which required more horses to draw it than his great waggon on wheels.

Nevertheless, precisely this difficulty—a greatly increased tractive effort was the rock on which for one hundred years and more inventions came to wreck. With the general adoption of mechanically-propelled road vehicles the cost of motive power became a less overwhelming consideration but still great tractive effort postulates great friction and friction means destruction. It is notorious that the life of the tracks of the original Tanks was only a few miles and the road resistance was in the neighbourhood of 600 or 700 lbs. per ton as compared with the 5 lbs. per ton of a railway waggon or the 60 lbs. per ton of a motor lorry on a good hard road. It is true that the road resistance of a wheeled vehicle rises rapidly as the surface deteriorates until on soft grass land or earth loosely ploughed, it will register up to 350-400 lbs. per ton. Indeed, under some conditions the vehicle will be absolutely stalled. But until such surfaces are reached the wheel is superior to the type of track that I have described hitherto—that is to say a rigid track consisting of plates hinged together in such a way that movement is restricted to one plane. Such a track is incapable of adapting itself to the ordinary irregularities in its path, and enough power has to be provided simply to brutalise them out of existence. The full effects and reasons of this phenomenon were not properly appreciated nor were adequate efforts made to overcome them until, in 1900, Diplock developed his Pedrail. The latter part of Diplock's life was devoted to perfecting a vehicle of the track character, the underlying principle of which was to allow individual and universal movement in each foot or plate of the track. He was the first clearly to recognise that until a perfectly flexible track had been developed—one which would adapt itself to all the minor irregularities and unevennesses of its road—no vehicle could be made on this system which could compete commercially for transport with the wheel.

There are sometimes conditions in agriculture and forestry where the ground is of so plastic a quality that it will readily conform to the rigid track, where the question of speed does not arise, and where the percentage of the power from the engine available at the draw bar is not of importance, that provide a limited field of usefulness for a rigid track machine which, with all its faults, will at least stay on the surface and haul when the driving wheels of a conventional traction engine would be spinning round and digging themselves in. But where cost per ton mile is the dominating consideration, where comparatively high speeds are desired and destruction of the surface traversed cannot be tolerated—in short, where transport as a common carrier is the end in view and not agricultural processes such as ploughing, etc., or haulage work in a limited area—then some adaptation, development or improvement of Diplock's idea of a flexible track is essential.

Remembering that this is a paper on transport in Tropical Africa and not on the mechanical development of track vehicles, I have to resist the temptation to discuss this feature further in intimate detail. I feel, however, that no reference to track vehicles can be made without explaining the vital importance of resilience and flexibility in the track mechanism of any such machines required for transport work.

Practical vehicles have now been designed which embody this flexibility of track and which can, therefore, be propelled with no greater consumption of power than a wheeled lorry of the same size on a hard road and I will now shew you a few illustrations.

Slide No. 4, one ton Guy Lorry for the Empire Cotton Growing Corporation.

The Empire Cotton Growing Corporation in its endeavours to increase the production of Empire grown cotton has, amongst its many other activities, taken up this question of transport and here is shewn one of the Corporation's purchases—a 25 cwt. Guy Lorry mounted on the track system developed by Roadless Traction, Ltd. This vehicle in so far as the radiator, engine, gear box, chassis, propeller shaft, differential and back axles are concerned, consists of a standard type 25 cwt. Guy Lorry. The front wheels and the steering are also standard, though they are relieved of a substantial proportion of the weight which they would carry in a normal 4 wheeled vehicle, part of the weight being thrown back on to the special tracks forming the novel feature of this type of lorry.

On the back axle two sprockets of a special design are mounted, which drive a belt of steel plates forged out of the solid. This endless belt of steel plates or feet driven by the sprockets on either side of the vehicle are about 11″ broad and run on two idlers about 4 feet centres from the driving sprockets on the back axle. The feet are hinged together by means of a special type of flexible joint which permits of universal movement, limited in extent but sufficient to enable the vehicle to turn on a radius of 15 feet without skidding. The sprockets and the idlers, together with that portion of the endless belt of feet surrounding them, do not normally come into contact with the ground.

The weight of the vehicle is carried on one four-wheeled bogie a side. The bogies are connected across the frame by a tubular cross axle mounted on the vehicle springs. The bogie wheels are tyred with solid rubber and run on the inside of the track. Each bogie is mounted on a ball joint giving universal movement limited by stops.

In actual demonstration the vehicle is found to run comparatively silently at a speed of 12 or 15 miles an hour on top gear. Road resistance is low and seems very little greater than that of an ordinary lorry on four wheels. A laden vehicle ran by its own weight, with the clutch out and the engine stopped, on a slope of one in 35.

Slide No. 5, Sentinel Roadless Tractor.

Here again we have the same type of track but fitted to a steam driven vehicle of the well-known Sentinel Steam Waggon Company of Shrewsbury. This is, of course, a bigger and heavier vehicle than that shown in the previous slide, but the principles embodied in the track are precisely the same.

Slide No. 6, Citroën Kegresse Car.

No description of track vehicles would be complete without a reference to the well-known trans-Sahara Citroën Kegresse Cars. The chief difference between this and the type previously illustrated is that here the track is made of a rubber composition so that the necessary flexibility is obtained without the introduction of metal joints.

Slide No. 7, Citroën Kegresse.

This view shows the vehicle crossing a swamp under conditions quite impossible for a wheeled vehicle.

Slide No. 8, Citroën Kegresse crossing a ditch.

Here we find very well illustrated the manner in which this modern type of track vehicle is capable of adapting itself to difficult country impassable to a wheeled vehicle.

There is now just one further point that I wish to make in regard to track vehicles in general. It was in 1916, on the appearance of the Tanks, that the first grand scale demonstration of the possibilities of this system was advertised to the world. The occasion was so important and the circumstances so dramatic that an indelible impression was created upon the minds of men. The wonderful exploits of these Juggernauts and their power to overcome seemingly impossible obstacles—to push down houses and to trample barbed-wire entanglements under foot—to climb in and out of shell holes half full of water; to take broken guns and German pill boxes in their stride, and, in short, to perform all sorts of spectacular feats—have come to be accepted as inevitable functions of such vehicles, and far more important and valuable attributes, from the point of view of commercial transport, are, perhaps, in consequence, apt to be lost sight of. It is a far better thing for a lorry, destined for industrial transport, to be able to pass fully laden over a soft track without cutting it up than to be able to push down a house: to pull a heavy load up a steep grassy slope without skidding than to take a six-foot trench: to register a low road resistance than to be impervious to rifle fire: and it is on this note of sober commercial usefulness that I wish to lay emphasis rather than on the more vivid characteristics required for war.

It is, in my opinion, to the use of these—and of other yet to be designed—track vehicles that we must look for the bridging of that " economic gap " in the transport systems of Tropical Africa to which I began by directing your attention. To bring 100 tons per month over a distance of 100 miles by present methods has been shown to be commercially impossible. Yet this is the sort of quantity and distance which, with increasing frequency, will present itself to be dealt with. Railways are too expensive, wheels are impossible without suitable roads, which are impracticable. The vehicle mounted on tracks offers a solution, though much, no doubt, remains to be done before these pioneers reach their full development. There are, however, mechanical resources which have as yet been hardly touched, and eager competitors ready to seize and adopt the lessons taught by practical use under tropical conditions. Success, ever more complete, resolves itself into a question of time.

DISCUSSION.

THE RT. HON. SIR FREDERICK LUGARD, G.C.M.G., C.B., D.S.O., said he proposed to confine himself to that side of the question on which he was best qualified to speak, namely, what was wanted in Africa in the way of transport. Mr. Ormsby-Gore, the Under Secretary of State, in giving an account to the African Society of his experiences in East Africa, had summed up the development of Africa in two words: transportation and population. Produce to be transported depended on population for its production; and labour for constructing railways and roads or other forms of transport also depended on population. On the other hand, however dense and industrious the population might be, it would be useless for it to produce unless it could get its produce to a port, and under present conditions the larger the bulk of that produce the greater the number of men who were withdrawn from productive enterprise to carry it on their heads to the nearest port. It had been calculated that produce worth £30 a ton would cost the whole of that sum to convey, by present methods, 200 miles, which meant that it was impossible to convey it by head carriage more than that distance. The only existing cheap method of transportation was by waterway. In Southern Nigeria there was a network of small creeks, on which canoes were largely used, but such produce as they transported was invariably considerably damaged. African rivers were exceedingly unnavigable; they were generally impeded at their mouths by bars, and at a comparatively short distance from the coast by rapids. They were only navigable by steamers of any size for a few months of the year.

The first need of Africa was arterial railways. A few days ago Sir John Eaglesome delivered a lecture at Leeds on the subject of African transport which would shortly be published in the Journal of the Institute of Transport, and gave some striking figures of the development due to railways. In Uganda, for instance, the output of cotton three or four years ago was 40,000 bales; for the present year it was expected to be 200,000. Sir John also said the General Manager of the Nigerian railway had told him that he expected a gross revenue of £2,000,000 and a net revenue of £1,000,000. Those were large figures, and the benefit accrued not only to British trade but also to the natives. Sir Humphrey Leggett had said that the native cotton producers in Uganda would receive £3,000,000, and the cocoa of the Gold Coast was worth £6,000,000 to the natives. Arterial railways were being constructed by the various colonial governments as fast as they could find the funds. The problem was how to feed them. It was said that roads should be made in Africa, but personally he strongly endorsed the lecturer's view that roads were impracticable. What was called in India the *kutcha* road—the mere track—would develop itself after the railway was constructed. The question was how those tracks should be made. He thought the first things required were bridges and culverts, with some clearing of the bush between them, and then a vehicle adapted to using such a track and which, instead of cutting it up, would improve it. The Diplock Pedrail seemed the best vehicle for that purpose he had seen up to the present, because the breadth of the revolving pad was greater than anything offered by vehicles which ran on an endless band. One such vehicle which the author mentioned had a band 11 inches in width, but if these vehicles followed each other in succession even an 11 inch band would plough up the tracks and create what, in the first tropical rain, would become a rut. What was wanted was something which would go over the ground like a roller. The broader the revolving band the better, because the vehicle would then improve the track instead of cutting it up. Another point about the Pedrail was that it could turn in a very narrow radius. A vehicle was wanted which had the weight well distributed, which would cross swampy land where there were 18 inches or 2 feet of water, which would carry about 2 tons and which would not be too heavy for the bridges which could be made.

The next problem, not less important, was that of fuel. Sir John Eaglesome in his paper spoke very highly of producer gas. Experiments had recently been made in the Gold Coast with the production of alcohol, and the Citroën cars which went to Lake Chad recently used palm oil. He hoped the subject of fuel would be explored by the Committee of the Empire Cotton Growing Corporation of which the author was a member, for it was as important and as difficult as anything connected with the question of transport in Africa.

Sir Robert Hamilton, M.P., said that, though not an expert in matters of road transport, he had spent the best part of his life in West and East Africa and had seen the difficulties experienced there owing to inefficient transport. He congratulated the author on the extremely practical nature of his paper. The extent to which inefficient transport impeded the development of our African colonies was not sufficiently recognised. Every man engaged in carrying a load on his head stood in the way of the development of the country from two points of view; in the first place, he was not producing anything himself, and, secondly, so long as it was attempted to get the produce of the country conveyed by head transport, there was little encouragement to the producer on a big scale to get on with his work. It was, therefore, of the utmost importance that efficient means of transport should be found.

He endorsed what the author had said with regard to macadamised roads. It was generally accepted nowadays that macadamised roads in Africa as feeders to railways were very expensive and not likely, owing to the cost of upkeep, to be efficient. Some other method had therefore to be found, and that advocated by the author consisted, not in having a good road, but in having a good vehicle which could use a cleared track. Personally, he thought that line was the right one; if one could not get a good road, but had to use an unequal, rough road, with swamps, and so on, one must get a car which would fit such a track.

He would like to know by whom cars such as the author described were being made. During a recent tour of South Africa, he had been astonished to find that 90 per cent. of the cars in use there were not of British manufacture, the reason being that British cars were not suitable for South African conditions. There seemed to be a great field open for the manufacture of such cars and tractors as the author had mentioned, and he hoped British manufacturers would avail themselves to the full of the opportunity.

MR. G. H. BAILLIE said he had been associated with the author in investigating, for the Empire Cotton Growing Corporation, the question of African transport. Mr. Brackenbury had brought out most clearly the gap which existed in means of transport in Africa, and the urgent need of filling that gap. Nobody was more alive to the necessity of doing so than the Empire Cotton Growing Corporation, and, as the Corporation would be the first to run the track type of vehicle described by the author under strictly commercial conditions, he thought a few details of the experiments it was making might be of interest.

The Corporation had set itself the task of increasing the supply of Empire-grown cotton, to replace the diminishing American supply. Areas suitable for growing cotton which were at present served by any form of transport were very limited, whereas those not so served were practically unlimited. Their development depended entirely on transport, and transport, therefore, was a big factor in the work of the Corporation. Until a district had reached a point in its development when a railway became feasible economically, everything pointed to a vehicle of the track type as providing the best possible solution of the transport problem. The difficulty was that no vehicle of that type had ever been run under commercial conditions. Heavy tractors of the caterpillar type had, it was true, been used for a long time, especially in America, and were invaluable for difficult haulage work, but they were quite unsuited for ordinary transport work where the cost per ton-mile was the all-important factor. The vehicle made by the Roadless Traction Company could be seen running by any one interested. It could carry out most remarkable "stunts," but the question was whether it could run regularly and show a commercial cost per ton-mile when doing steady, slogging transport work. That was what the Empire Cotton Growing Corporation was going to find out, by testing, under actual conditions of transporting cotton, any type of vehicle likely to show good commercial results. It intended to test not merely one vehicle but the whole type, to see whether that type, or improvements of that type, would eventually become commercially successful. He was sure the results of those experiments would be awaited with interest by all who had to do with African transport.

Sir Frederick Lugard had referred to the question of fuel. That question had already received the closest attention of the Corporation, which intended to try certain fuels such as charcoal fuel used in a gas producer and locally-produced alcohol. For the present, however, it was keeping to the wise policy of one thing at a time.

A point which militated to some extent against the track vehicle was its initial cost. If a lorry could be run a hundred miles a day with a full load it would not matter what it cost, because the capital charges would work out at about a penny a mile, but the actual conditions of operation were very different, especially in the case of cotton, which was a seasonal industry requiring transport for only some four months in the year. A lorry intended primarily for cotton would do other work for the rest of the year, but it was bound to be idle, or running on light loads, for a considerable portion of the time, and capital charges formed an important item in the cost per ton-mile. A low initial cost for the vehicle was, therefore, essential if it were to come into general use. He hoped some manufacturer would do for the heavy lorry what Ford, Morris and Citroën had done for the touring car, and that, as a result of the paper, people would no longer regard track vehicles as queer freaks, but would realise that they had great possibilities.

Mr. P. H. Johnson, C.B.E., D.S.O., M.I.M.E. (Joint Managing Director, Roadless Traction, Ltd.) thought that, just as at the present time the introduction of steam was regarded as having contributed materially to the regeneration of Europe after the Napoleonic wars, so in the future people would look on the introduction of efficient means of cross-country transport as having contributed very materially to the economic recovery of the world after the war of 914-1918. He ventured to think that, though the author was dealing only with tropical Africa, his remarks had world-wide application. Personally, he thought there were roadless problems even in this country. He agreed with what the author said as to the limitations of wheeled vehicles, though the very light, pneumatic-tyred type of vehicle which could traverse comparatively bad surfaces could accomplish useful work. On the other hand, the cost per ton-mile when dealing with such small quantities was invariably high.

He had attended, the previous week, some trials organised by the War Office in Dorset, for which, in addition to track vehicles, a number of wheeled vehicles —six wheels, four driven, and so on—were entered. He thought every one who witnessed those trials had been convinced of the definite superiority of track over wheeled vehicles. The course was undoubtedly severe, but in many places no worse than would be found in tropical Africa. Broadly speaking, there were two classes of track vehicles, both of which had been referred to by the author. One had an all-metal track, and the other a track made of rubber and fabric. He thought there was a big field for both types, certain conditions rendering one type suitable and others the other. It was probable that in future yet other types would be developed. The types of tracks and of roadless vehicles which would be developed were simply limited by the variety of the conditions to be met. It was a law of evolution that, until the necessary conditions were met, evolution must proceed, and, just as conditions off the roads were more varied than conditions on them, so there would probably be a greater variety of roadless vehicles than of road vehicles.

In regard to the question of cost, he wished to make a suggestion which he thought would be useful from the military standpoint. He suggested the War Office should hold trials rather different from those held the previous week. The latter were designed to show which was the best type of vehicle to traverse a certain very difficult course; he suggested the next trials should be organised on a basis of cost per ton-mile. It might be thought that the military authorities were not interested in cost per ton-mile, but he believed they were. They could not maintain during peace the number of vehicles they would require in case of war, and if there were no manufacturing organisation capable of producing those vehicles they would have nothing to fall back on. It was in their interest to develop a commercial vehicle of the kind in question, and if they organised trials on the basis of cost per ton-mile, and the figures obtained were circulated all over the world, they would be read with great interest by people like mining and plantation managers and engineers, who, if they found them lower than their present figures, would consider the possibility of utilising the new vehicles. Apart from that, it would assist the manufacturers, the export trade, and the development of the Empire. He thought the trials should be firstly on the basis of cost per ton-mile, and secondly—a very important point—on lack of damage to the surface traversed. He hoped the Chairman would bring the matter to the notice of the War Office.

The question of cost per ton-mile had been raised. The author had not dealt with it in detail, and it was difficult to do so, because it was necessary first to know the conditions, and the conditions were almost infinitely varied Broadly speaking, he thought the cost per ton-mile of the roadless vehicle would be much the same as for a similar type on wheels with similar weight-carrying capacity on a fair road. The roadless vehicle would be rather more expensive to run, and its first cost would be higher, especially to start with, when very few of them were being manufactured, but the greater adhesion obtained by the use of tracks instead of wheels would give it a capacity for hauling a load which the wheeled vehicle on roads did not possess, and could not utilise if it did owing to the limitations imposed by the road and the traffic on it. The cost per ton-mile must, of course, vary with the bulk of the load, as was the case with railways and steamships; the larger the paying load, the less the cost per ton-mile. He thought, therefore, that in the near future very large types of roadless vehicles would be demanded. One limitation to that process was the carrying capacity of bridges, and he suggested that when any one decided to build a bridge in Tropical Africa to carry a certain weight he should think again and double it.

The author had referred to the Sentinel tractor, which had a haulage capacity of about 20 tons net load, the drawbar pull being about 6 tons. The Sentinel people had worked out the cost of that, including overhead charges, depreciation, interest on capital and all running charges, and allowing for a 20 tons net load for a reasonable number of working days in the year, as 1⅞d. per ton-mile. He was certain that figure needed considerable adjustment for work in Tropical Africa, and thought 3d. per ton-mile, or at most 4d., would probably be a fair figure, but that would only apply on the basis of hauling 20 tons at a time; for smaller loads it would be more expensive. Wherever it was possible to run the heavier type of vehicle, and suitable loads were available, the cost per ton-mile would naturally be low; but he thought even the smaller types would be able to compete with head porters, pack animals and the less efficient forms of animal transport, thus leaving the labour and the animals of the country free for other purposes.

Colonel Sir Sydney Crookshank, K.C.M.G., C.B., C.I.E., said that on the Gold Coast (including its Dependencies) the transportation problem was practically confined to the railway, which was of 3′ 6″ gauge, and the road. Far from restricting the development of the road systems, the authorities, as far as he knew, intended to expand them on a large scale. It was found that what were called in India *kutcha* roads, that is to say, roads surfaced with laterite gravel, were able to stand up to traffic amounting to as many as 800 motor vehicles per diem during the cocoa season on certain sections. With traffic as heavy as that the laterite road was expensive to maintain, but by renewing the surface with 3-inch macadam, tarred on the penetration method, its life could be greatly prolonged, and the maintenance costs could be reduced from £120 a mile to, perhaps, £30 or £40 per mile per annum. Traffic could, at the same time, be considerably increased when the road was so treated. The Government was, he was given to understand, about to spend up to something like £1,000,000 in tar-matting the main trade roads and in road development generally. Firms on the Gold Coast had recently experimented with the " creeper " motor vehicle, but, though no doubt it was useful under certain conditions, it had to give way to the ordinary wheeled vehicle when the volume of traffic increased, and for that reason there did not seem to be any great future for that form of transportation in the Colony. It had been found that as soon as a road was passable for mechanical road transport—*i.e.*, as soon as it had bridges and was open even to track wheel motor transport—the demand for faster traffic grew to such an extent that it became necessary to macadamise the road with laterite or metal in due course.

Motor road transport on the Gold Coast had developed some rather interesting features. Hitherto it had been considered that 40 to 50 miles from railhead was as far as it was economically possible to carry agricultural produce by road. It had now been discovered that with commodities like cocoa, road transport could advantageously extend over far greater distances—up to 100 miles—at a cost of 10d. per ton-mile (excluding overhead charges), which, on the Gold Coast, compared very favourably with rail transport, since the latter involved handling at both ends and delivery charges in addition to the ordinary railway freightage. There was no occasion to fear competition between road and rail transport.

He wished to urge the Empire Cotton Growing Corporation to give its attention to the Gold Coast, where there was a field for cotton growing capable of immense development. At present there was no irrigation, but he was certain there were opportunities for irrigation and cotton growing. Due consideration should be given to the important part which road construction and development played in countries like India and Africa. Much depended on the materials available, and where such materials were not to be had cheaply, road construction would not be a paying proposition. In some parts of Africa, however, there was a very great future before the development of roads.

Sir William M. Acworth, K.C.S.I., said his knowledge of tropical conditions had been gained by looking out of the window of a saloon carriage during some ten thousand miles of travel. From what he had seen in that way he had come to two conclusions. In the first place, he saw that it would be impossible to build railways sufficient to gridiron the country to the extent that was necessary; secondly, he came to the conclusion that a road that would stand up to heavy motor transport would be about as expensive as a railway. Sir Sydney Crookshank's remarks had rather startled him; if, on the Gold Coast, roads which were made with very little preparation would stand up to 800 lorries per diem at an expenditure of £30 per annum, that seemed to alter the conditions altogether. He thought the Gold Coast experience should be made available, at the public expense, to all the road surveyors in England, for they would be able to save millions a year !

Personally, he had formed the conclusion exactly contrary to Sir Sydney's, namely that roads were impossible, because, having regard to their cost, they could not be built close enough together ; one would have to go across country for a good many miles to get to a road or a railway.

He had been invited to see a roadless tank before it developed from a tank into a commercial vehicle. He sat on the conning tower and went across fairly rough country at 25 miles an hour. It had been an absolute revelation to him, and afterwards he had had the effrontery to tell a firm of motor manufacturers of his acquaintance that they ought to go in for tanks, as they were the machines of the future. He had also said to railway men, not only in Africa but in the Argentine, that the day of railway development by means of light railways was, in his judgment, over, and that serious consideration should be given to the question before any more were built.

Light railways were handicapped by a considerable capital expenditure, which the author put at £5,000 per mile. That meant £300 a year for interest, and another £200 a year must be added for maintenance, irrespective of the amount of traffic carried. That meant £500 a year to have the railway there ready for use, and in addition to that there were the expenses of carriage. The author spoke of 1,000 tons per mile per month. On the basis of £500 for getting the railway there, that was about 10d. a ton-mile. Then there would be the carriage, which would not be less than 4d. He did not believe it was good business to spend money on railways if they would not be remunerative within a reasonable number of years. He knew of a railway which had been open fifteen or twenty-years, and which carried one train each way every other day. One was not justified in building a railway under such conditions. The railways most people were accustomed to carried goods in both directions. Rhodesia, which was a tropical country, had a considerable import traffic over long distances, because it had a white population, and a white population would buy manufactured goods in large quantities ; but the native would probably import little but beads and cotton handkerchiefs ; the importation up country must be very small. With regard to the traffic down, he could not pretend to estimate the production of different tropical commodities, but he was sure it must be very small for the area.

To take an instance with which every one would be familiar, a wheat field produced 4 quarters to the acre, or about ¾ ton. A square mile, 640 acres, would produce about 450 tons of wheat in a year, say, two train loads. If one considered what a railway ought to carry to make it of any use, it was quite obvious that, to get sufficient traffic to justify it, it must serve either thick traffic close to it or a wide area. If it were a question of serving a wide area, he was convinced that the track vehicle would be able to compete successfully with the road. He was grateful to the author for having supported what he himself had urged without one-tenth of the knowledge behind him which the author had.

The question of bridges had been mentioned. Bridges in a tropical country liable to floods were an expensive item. Some time ago he spent a summer near a little creek on the coast of Brittany where the tide rose about 40 feet, which approximated to the flooding of a river in the monsoon period. A bridge was used which spanned the stream which came down in normal times ; when there was a flood (*i.e.*, when the tide rose) it was impossible to cross. It might be worth while to save a great deal of money when building bridges over some tropical streams to erect one which would be expected to be out of use for four or five weeks in the year, but which would be all right for the rest of the time. He had never heard that idea suggested by English engineers, but it would save an enormous amount of money.

Lt.-Col. F. D. Hammond, C.B.E., D.S.O., agreed with all the author had said, but wished to join issue with Sir Sydney Crookshank. Personally, he had been struck, in all the parts of Africa he had visited, by the fact that the problem of feeders to railways had never yet been properly solved. Great things had been done in the matter of transporting cocoa on the Gold Coast with light lorries (to the importance of which the author did not, perhaps, give sufficient credit), but he did not think they possessed all the merits Sir Sydney claimed for them. Sir Sydney's figure of 10d. per ton-mile must be rather exceptional; the best figure he himself had met with was 9d., and that for a large corporation which had a heavy load in both directions; moreover, the 9d. did not include the damage done to the road. Tenpence per ton-mile, however, was a very high cost; very few raw materials could stand it over a long distance.

If the gap to which the author alluded were to be bridged by means of track vehicles, there were two points to which those who manufactured them should give special attention. Firstly, if cheapness of operation was desired there must be haulage as well as load on the vehicle, and, secondly, the machine must be as foolproof as possible.

Captain Frederic Shelford, M.Inst.C.E., wished to repudiate Sir William Acworth's suggestion that no one had ever thought of making a bridge across a river which would be submerged for part of the time. In Cyprus, where he had built a railway for the Colonial Office, two or three rivers were encountered which were almost dry for nine months in the year, but which were half a mile to a mile wide when in flood. It was decided that the best method of bridging them was to make a causeway, and so a low causeway was built. When the rivers were in flood the water ran over the causeway, but at other times trains could cross.

Mr. Brackenbury, in reply to the discussion, said Sir Sydney Crookshank had spoken about roads on the Gold Coast, but it must be remembered that the Gold Coast was a very shallow colony; it did not run back any distance from the coast. Moreover, the type of "creeper" vehicle Sir Sydney described was not the modern type at all. In his paper he had drawn a clear distinction between those with rigid and those with flexible tracks. As Sir William Acworth had stated, the flexible track type would travel at 25 miles an hour—as fast as any lorry. The great difference between the two types of vehicles was that the flexible track vehicle would carry a big load, whereas the wheeled vehicle could only carry a comparatively small one. For carrying produce, particularly over long distances, there was no doubt that the loads must be more than 2 or 3 tons; they should be in the neighbourhood of 10 or 15 tons—a tractor carrying not less than 6 tons with trailers behind it. Even in England it had been found that small capacity lorries could not be used economically unless the distances concerned were very short.

Mr. Johnson's suggestion that the War Office should encourage the development of vehicles for commercial rather than strictly military purposes, with the idea that if war broke out they could be used for transport purposes, was, he thought, excellent, though he doubted whether a fighting service was well equipped to deal with such an essentially commercial question as cost per ton-mile.

The Chairman (Major-General Sir Ernest Swinton), who had to curtail his concluding remarks owing to pressure of time, said that he was sure that the audience had been greatly impressed by the lecturer's presentation of the subject from the point of view of population density, and by the manner in which he had made it clear that in those regions where transport was in urgent demand, but the existing volume and lack of regularity of traffic did not justify the cost of providing roads or railways, some intermediate means between the latter and the primitive methods of human or animal carriage must be sought.

There was a saying that if the mountain could not go to Mahomet, Mahomet would have to go to the mountain. In transport matters our efforts in the past had usually been directed to making our mountain—the surface of the earth, suitable to Mahomet—our vehicles. But when this could not be done economically it was surely wise to try to adapt our vehicles to suit the surface.

This would apply, as had been so well brought out, to the embryonic and comparatively puny feeder communications leading to the main arterial systems of roads and railways, which like large rivers would convey the traffic accumulated from their tributary streams of less capacity and varying type. In the course of time many of these feeders might eventually themselves become consolidated and move up in the scale of transport evolution.

At the moment the opening up of Africa, the country with which Mr. Brackenbury was concerned, with its great economic future, was absorbing much attention, especially in the direction under consideration. Above the ground air routes were being established by the French. On the ground, in addition to railway and road construction, various cross-country pioneer experimental expeditions had been carried out and were going on. There was the recent wheeled motor car journey of Mr. Galton Fenzi across Tanganyika and Kenya, and that in progress from the Cape to Cairo of Major Court Treatt. The French were very active. At the beginning of last year M. Haardt had carried out the Trans-Saharan trip to Timbuctoo and back in Citroën-Kegresse caterpillar-track motor cars. The success of this had led to the organisation of a regular service of similar machines to and from Timbuctoo, the inauguration of which had been postponed for reasons unconnected with transport. Amongst other expeditions was that of Captain Delingette, whose party in motor cars had reached Irumu in the Belgian Congo, on its way to Nairobi and Cape Town. On the whole the French seemed to be much alive to the necessity for experimenting in new methods applicable to the particular conditions of the great continent in which both countries had so large an interest.

On the military side the subject was also attracting interest. Comprehensive trials had just been carried out by the War Office of wheeled, tracked, and half-tracked machines for cross-country transport as apart from fighting, which, though for a special purpose, should be helpful in regard to the commercial problem.

It had been most valuable to hear the views of a man like Mr. Brackenbury, who not only knew the technical side of what he was discussing, but was also possessed of an analytic mind and constructive imagination. It was to be hoped that what he had said would stimulate some practical steps. He had great pleasure in proposing a hearty vote of thanks to Mr. Brackenbury for his paper.

Sir Humphrey Leggett, D.S.O., seconded the vote of thanks to the author and proposed one to the Chairman, who was certainly a leading authority in the British Empire on the problem of cross-country transport, or, as he had just put it, of adapting the vehicle to the surface when it was not possible for one reason or another, cost or what not, to adapt the surface to the vehicle. They had that day been listening to ideas that were a really constructive piece of Empire building. With an irresistible logic, and sober business argument—the argument of the cost per ton-mile—Mr. Brackenbury had shown that there was a vital gap, to be bridged between the potential producer of the world's needs of foodstuffs and raw materials in Tropical Africa, and the arterial lines of the world's communications. Unless and until the gap was bridged, those potential producers were blanketted, and he would add that they were largely blanketted also as to their power to be buyers and consumers of the goods made in the factories at home. The need to develop this production, and the reciprocal capacity for consumption, was never greater than it was to-day, and what the potentialities in this direction were could be read in Sir Frederick Lugard's great book, "The Dual Mandate," which showed vividly the increasing dependence they all had upon the development of Tropical Africa, our duty to those regions and their inhabitants, and their duty to the rest of the world in return.

Mr. Brackenbury had shown them how the problem was already being experimented with, but obviously much remained to be done, and no doubt it never could be finally done, for there would always be scope for improvement. Much patient work, directed with vision and enthusiasm, was required. He remembered his first interview with Mr. Brackenbury ten years ago, in the private paddock of the Bishop of London, at Fulham Palace, where the lecturer was engaged in experimental work, on the orders of Mr. Winston Churchill, on a form of caterpillar tractor, to carry heavy guns, etc., over piles of broken bricks and other such bunkers. It was patient and systematic experimental work like that that was so much needed for the solving of the problem of the " transport gap " in Tropical Africa.

He respectfully commended a suggestion to those who had influence with the authorities responsible for the welfare and future of Africa. Barely a fortnight ago the present Under Secretary of State for the Colonies, Mr. Ormsby-Gore, in a public speech, adumbrated a programme of railway development in the East African group of countries that would cost, the speaker thought, about ten millions sterling over the next five to ten years. He was not aware of the West African programme, but it might be as large. And no one would say that these projects were not justified, and indeed necessary, for they would add vastly to the productive and consuming powers of those countries. But they would not in themselves bridge the transport gap between the producer and the arterial lines of communication. Only cross-country transport, economical and efficient in type and design, could do this, as the logic of the lecturer had shown. Such cross-country transport was, in fact, the feeder of the railway lines, and the solution of the problem meant more traffic and revenue to the railways. Was it then too much to suggest that, say, a mere one per cent. of what was to be spent upon these railway lines should be set aside for concurrent, thorough, persistent and continuous research and experimentation of the cross-country transport problem ? Let them think what work could be done, and what results should be possible, if a fund of say £100,000—one per cent. only of the ten millions—were placed at the disposal of a standing *ad hoc* committee, empowered to experiment and test in every way, under an expert director, in the same way as the foundations of aircraft manufacture were laid by the War Office aircraft experimental station and factory at Aldershot before the war. He did not suggest that the proposed fund, and the control of the cross-country transport experimental work, should be under the War Office, for though that department might be glad to take a hand, the essence was that the work should be on the commercial plane, first, second and all the time. He knew that something of the kind was being done by the Empire Cotton Corporation—Mr. Brackenbury had mentioned that—and no doubt it was useful, but he did say that the problem was so vital, and the results of its solution would be so gigantic, that it was worth much more expense and effort than could possibly be put into it by a sub-committee of the Empire Cotton Corporation, with its necessarily very limited funds. That was a task that must take years, and even when partly solved could always be improved upon, and the work should be continuous and not allowed to drop. Speaking as a business man, he could hardly conceive of the railway administration that would not be glad to devote one per cent. of its resources to research work that should double or treble its revenue, not once but for all time. Might he venture the hope that that suggestion would receive consideration ?

The motion was carried unanimously.

CORRESPONDENCE.

ANGLO-INDIANS AND DOMICILED EUROPEANS IN INDIA.

In your *Journal* of 27th February there is a letter from Mr. R. à-Ababrelton, in which he raises the question whether the Anglo-Indians are disappearing as a race, or whether their numbers are kept up by fresh accessions.

I enclose a copy of a memorandum recently published by my Association, in which the question raised by Mr. à-Ababrelton is fully explained. A copy of this memorandum was sent to the Members of both Houses of Parliament, and in a leading article in the *Times* of 3rd January, 1925, attention was drawn to it. If there is any further information Mr. à-Ababrelton desires, I shall be pleased to furnish it.

H. A. Gibbon,
Hon. Secretary.

Anglo-Indian Association, London,
88, Merton Hall Road, Wimbledon, S.W. 19.

[The memorandum referred to in the above letter mentions that the " permanent British population of India " is " divisible into two sections—(1) persons of British descent through both parents, and (2) persons of British descent on the father's side," and numbers some 200,000.]

LA VIE INDUSTRIELLE EN FRANCE

Le Laboratoire de Psychotechnique de la Societe des Transports en Commun de la Region Parisienne.

On vient d'inaugurer à Paris le laboratoire de psychotechnique que la Société des Transports en commun de la Région parisienne a installé pour la sélection de son personnel.

La psychotechnique est l'étude des facultés humaines en vue de leur meilleure utilisation technique. Elle a été déjà appliquée, pendant la guerre, au recrutement des mitrailleurs et des aviateurs, et; depuis, elle sert pour le choix des individus aptes à certaines professions, tels que conducteurs d'automobiles, dactylographes, etc.

Le laboratoire de psychotechnique de la S.T.C.R.P. applique les méthodes reconnues jusqu'ici les meilleures, et est muni d'un outillage très perfectionné. L'examen auquel sont soumis les candidats aux postes de conducteurs d'autobus ou de tramways comporte de nombreuses épreuves ou "tests" originaux, permettant d'évaluer les facultés des candidats pour: l'attention diffusée, les réactions motrices, l'appréciation des vitesses et des distances, la rapidité de perception des images, le repérage de la direction des sons, l'émotivité, la mémoire, etc.

Un premier test est celui de la force musculaire localisée dans la main. Il est réalisé au moyen du dynamographe Henry, qui se compose d'une poire en caoutchouc remplie de mercure et surmontée d'un tube de verre. Le sujet presse la poire, ce qui soulève la colonne de mercure, et maintient la pression aussi fortement qu'il peut. La pression s'enregistre sur un cylindre tournant placé derrière l'appareil.

Pour mesurer la suggestibilité motrice, on emploie l'appareil de Binet, constitué de deux petites roues solidarisées partiellement par une courroie. L'opérateur en commande une et le sujet, l s yeux bandés, commande l'autre; il doit suivre exactement les mouvements de l'opérateur, d'après l'impulsion qu'il en reçoit. Les mouvements de deux roues sont enregistrées sur un même cylindre, côte à côte.

L'aptitude des candidats à apprécier les vitesses est évaluée au moyen du tachodomètre. Cet appareil est constitué par une longue règle graduée, sur laquelle se déplacent des voyants, à vitesses diverses. Le sujet doit désigner, le plus rapidement possible, la division de la règle devant laquelle les voyants se rencontreront; on note les erreurs, et la rapidité avec laquelle la réponse est faite.

La rapidité de réaction est mesurée par le temps que mettent les candidats à répondre par un geste à un signal fait par l'opérateur. Ils doivent appuyer sur une manette aussitôt qu'ils perçoivent un son donné. La rapidité de réaction est mesurée en centièmes de seconde.

L'épreuve dite d'attention diffusée est la plus sévère, et aussi la plus significative. L'attention diffusée correspond à la qualité du machiniste qui doit observer plusieurs phénomènes, et réagir différemment pour les uns et les autres, tout en demeurant indifférent à d'autres phénomènes.

Pour évaluer cette qualité, on place le sujet dans une chambre noire, assis et ayant les pieds posés sur deux pédales. On allume sucessivement des lampes de trois couleurs distribuées en différents points de la salle; pour chaque couleur, le sujet doit opérer une manœuvre différente des pédales. On note les erreurs commises, et le temps de réaction, c'est-à-dire la durée écoulée entre l'allumage de la lampe et la manœuvre effectuée par le sujet.

Dans une seconde partie du test, on combine des sonneries avec des excitations lumineuses. Pendant toute l'expérience, on projette un film cinématographique, qui occasionne des distractions analogues à celles que le spectacle de la rue peut occasionner au wattman sur sa plateforme.

Tandis que le sujet est attentif aux excitations lumineuses et auditives, on crée des émotions de surprise; par le son brutal d'un klakson, que l'on fait fonctionner à intervalles irréguliers. La succession des phénomènes: allumage des lampes de diverses couleurs, sonneries, bruits parasites, etc., est réglée une fois pour toutes, en même temps que la projection du film. Elle s'enregistre sur un cylindre enregistreur sur lequel toutes les réactions du sujet s'inscrivent également.

Une fois l'épreuve terminée, on possède donc un document indiquant exactement comment le sujet a répondu aux différentes excitations.

D'autre part, le corps du sujet est placé pendant l'expérience dans un circuit électrique à faible tension (2 volts), sur lequel est branché un galvanomètre. A chaque coup de klakson, qui produit un choc émotif, on constate une déviation du spot du galvanomètre. En observant ces déviations successives, on peut juger si le sujet s'habitue aux émotions, ou au contraire si leur effet s'aggrave.

D'autres essais servent à évaluer différentes qualités du sujet, telles que la mémoire, le repérage des sons, etc.

L'examen psychotechnique permet de choisir parmi les candidats ceux qui seront susceptibles de faire des machinistes convenables et d'éliminer de suite ceux dont l'apprentissage serait impossible, et ceux qui pourraient être dangereux.

D'autre part, on fait passer un nouvel examen à tous les machinistes qui ont causé un accident, afin de vérifier si leurs facultés n'ont pas été atteintes. Enfin, la Société se propose d'examiner à intervalles réguliers tout le personnel conduisant les véhicules.

LA MISE EN SERVICE DE L'USINE ÉLECTRIQUE DE CHANCY-POUGNY SUR LE RHÔNE.

La Société des Forces Motrices de Chancy-Pougny va mettre en service sa grande usine-barrage, construite sur le Rhône à 15 kilomètres en aval de Genève, dans la partie où le Rhône forme la frontière franco-suisse.

Le barrage crée une chute de 9 mètres environ, et l'usine, placée à la suite de ce barrage, contient 5 groupes électrogènes avec turbines verticales Francis (8,700 h.p.) débitant jusqu'à 90 mètres cubes par seconde, et actionnant directement des alternateurs verticaux de 7,000 kilowatts.

Le courant, produit à 11,000 volts, est aussitôt transformé à 120,000 volts, et livré à la Société " Rhône et Jura," qui le transporte par une ligne aérienne double jusqu'à Ecuisses (Saône-et-Loire), près du Creusot.

Ce courant alimentera les usines Schneider du Creusot, et les Mines de houille de Blanzy, ainsi que d'autres industries de la Bourgogne et du Nivernais.

LE RENFLOUEMENT DE L'EPAVE DU CUIRASSE " LIBERTE," A TOULON.

En 1911, le cuirassé "*Liberté*," mouillé en rade de Toulon, fut coulé et en partie détruit par une explosion dans les soutes. De cette catastrophe résultait une grave difficulté pour la navigation en rade de Toulon, navigation intense, puisque Toulon est le principal port de guerre français en Méditerranée.

Les projets de renflouement de l'épave, qui comprend à peu près la moitié du navire primitif, et qui est coulée par un fond de 12 mètres seulement, fut suspendu pendant la guerre, et repris seulement en 1921. Il vient d'être enfin couronné de succès, et l'épave a pu être remorquée en février dernier, dans un bassin de l'arsenal, pour y être démolie.

Ces travaux ont été longs, très coûteux et très difficiles ; ils ont été confiés à une entreprise privée, qui opéra au moyen de l'air comprimé, d'abord pour arriver aux soutes et enlever les obus qui s'y trouvaient encore, puis pour amorcer le renflouement, que devaient faciliter des flotteurs (anciens sous-marins) accrochés à l'épave. Mais celle-ci était si pesante et si enfoncée dans la vase, qu'on eut une peine extrême à la décoller du fond. Il fallut refaire sous l'eau certaines cloisons étanches que l'explosion avait disloquées, pour épuiser ensuite à l'air comprimé les compartiments correspondants, et multiplier les flotteurs. Les chalumeaux oxyacétyléniques spéciaux, fonctionnant sous l'eau, rendirent ici de grands services aux scaphandriers, pour couper les tôles du navire, tordues et déchiquetées par l'explosion.

NOTES ON BOOKS.

CATALOGUE OF THE COLLECTION OF EUROPEAN ARMS AND ARMOUR FORMED AT GREENOCK BY R. L. SCOTT. Described by Felix Joubert, F.S.A. (Scot.). 3 vols. Privately Printed.

Mr. R. L. Scott has presented to the Society a copy of this magnificent catalogue, which has been produced for private circulation and is limited to a hundred copies. The work is divided into three volumes; the first deals with armour, helmets, horse armour and spurs; the second with swords and daggers, hunting weapons, shields and hafted-weapons; and the third with crossbows and fire-arms.

Mr. Scott's collection must be among the finest in private hands; it contains many notable pieces, such, for instance, as the extremely rare tilting helm from the collection of Captain H. Lindsay, which was described by Viscount Dillon in the proceedings of the Society of Antiquaries, and by Sir Guy Laking in his "European Armour and Arms."

The complete suit of equestrian armour for man and horse, which is illustrated in the first plate, is another extremely interesting piece. It is from the Greenwich workshops. "The entire surface is of russet steel, decorated with etched bands of a foliated design and gilt, and assembled together by latten headed rivets." This piece came from the Earl of Pembroke's collection.

A three-quarter suit of armour of Savoyard workmanship in the early part of the seventeenth century is also of exceptionally fine quality. The surface of *pavanazzo* blued steel is decorated with a scroll design, engraved and gilt, and the full-page illustration gives an excellent idea of the beauty and delicacy of the craftmanship.

The whole catalogue is a model of what such a work should be. Mr. Joubert's descriptions are severely concise, but adequate; the numerous plates are admirably reproduced, and the paper, type and binding are all chosen with excellent taste.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock :—

APRIL 22.—CEDRIC CHIVERS, J.P., Mayor of Bath, "Bookbinding." J. M. DENT will preside.

APRIL 29.—LIEUT.-COLONEL ANDREW BALFOUR, C.B., C.M.G., M.D. (Edin.), B.Sc., D.P.H., F.R.C.P.E., "The Trend of Modern Hygiene." SIR GEORGE NEWMAN, K.C.B., M.D., D.C.L., F.R.C.P., Chief Medical Officer, Ministry of Health, will preside.

MAY 6.—AIR VICE-MARSHAL SIR WILLIAM SEFTON BRANCKER, K.C.B., A.F.C., Director of Civil Aviation, Air Ministry, "Commercial Aviation." HIS GRACE THE DUKE OF SUTHERLAND, President of the Air League of the British Empire, will preside.

MAY 13.—(Joint Meeting of the Royal Society of Arts, the Royal Aeronautical Society, and the Anglo-Batavian Society.) THOMASSEN À THUESSINK VAN DER HOOP, "The Flight to the Netherlands East Indies." (The paper will be read in English). AIR VICE-MARSHAL SIR WILLIAM SEFTON BRANCKER, K.C.B., A.F.C., will preside.

MAY 20.—PROFESSOR JOHN AMBROSE FLEMING, M.A., D.Sc., F.R.S., "William Sturgeon and the Centenary of the Electro-magnet." ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council of the Society, will preside.

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

MAY 8.—SIR GILBERT T. WALKER, C.S.I., M.A., F.R.A.S., Sc.D., Ph.D., F.R.S., "Indian Meteorology."

MAY 22.—SIR ALFRED CHATTERTON, C.I.E., B.Sc., Assoc.M.Inst.C.E., "The Industrial Progress of the Mysore State."

JUNE 12.—BRIGADIER-GENERAL SIR PERCY M. SYKES, K.C.I.E., C.B., C.M.G., "The Heart of Asia and the Roof of the World."

DOMINIONS AND COLONIES SECTION.

Thursday afternoon, at 4.30 o'clock:—

JUNE 18.—HON. W. G. A. ORMSBY-GORE, M.P., Under Secretary of State for the Colonies, "East Africa."

DOMINIONS AND COLONIES AND INDIAN SECTIONS. (JOINT MEETING.)

Thursday afternoon, at 4.30 o'clock:—

APRIL 16.—THE RT. HON. LORD STEVENSON, G.C.M.G., "The British Empire Exhibition, 1925." SIR CHARLES CAMPBELL MCLEOD, Bt., will preside.

HOWARD LECTURES.

Monday evenings, at 8 o'clock:—

PROFESSOR JOHN SAMUEL STRAFFORD BRAME, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, "Motor Fuels." Three Lectures. April 20, 27, May 4.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

◆

MONDAY, APRIL 6..Chemical Industry, Society of, (London Section), at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 8 p.m. Prof. W. A. Bone, "The Constitution of Coal."

Victoria Institute, Central Buildings, Westminster, S.W. 4.30 p.m. Dr. E. Ash, "Psychotherapy: Mind in Curative Action."

Surveyors' Institution, 12, Great George Street, S.W. 8 p.m. Col. H. F. Bidder, "The Law of Evidence."

Geographical Society, 135, New Bond Street, W. 8.30 p.m. Major-General Sir Percy Cox, "A Journey Behind Muscat to the Jebel Akdhar."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 7 p.m. (Informal Meeting.) Discussion on "Insulation Problems in High-Voltage Engineering."

(Western Centre.) 6 p.m. Mr. S. T. Allen, "Radiators and Heating, with special reference to Material."

Transport, Institute of, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C. 5.30 p.m. Air Vice-Marshal Sir W. Sefton Brancker, "The Lessons of the Indian Flight."

Engineers, Society of, at the Geological Society, Burlington House, Piccadilly, W. 5.30 p.m. Mr. E. R. Matthews, "Problems in Designing and Constructing Sea Defence Works."

TUESDAY, APRIL 7..Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 5.30 p.m. Mr. J. S. Lewis, "Vapour Pressures of Binary and Ternary Fuel Mixtures."

Anthropological Society, 52, Upper Bedford Place, W.C. 8.15 p.m.

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C. 8.30 p.m. Mr. W. C. Noxon, "The Hydro-Electric Development of the Province of Ontario."

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m.

Mechanical Engineers, Institution of, (S. Wales Branch.) at the Chamber of Commerce, Swansea. 6 p.m. Mr. D. Wilson, "Powdered Fuel and Its Relation to Modern Power Plant Design."

Zoological Society, Regent's Park, N.W. 5.30 p.m. 1. Mr. F. G. S. Whitfield, "The Relation between the Feeding-habits and the Structure of the Mouth-parts in the Asilidæ (Diptera)." 2. Mr. O. Thomas, "On the Mammals obtained by Mr. Herbert Stevens on the Sladen-Godman Expedition to Tonkin." 3. Mr. W. M. Le Gros Clark, "On the Skull of *Tupaia minor*." 4. Dr. R. H. Hunter, "The Extensor Muscles in the Hind-foot in Mammals."

Marine Engineers, Institute of, 85, The Minories, E. 6.30 p.m. Capt. P. T. Brown and Mr. M. M. Parker, "Steering of Ships."

Electrical Engineers, Institution of, (Scottish Centre), 207, Bath Street, Glasgow. 7.30 p.m. Mr. E. A. Watson, "The Economic Aspect of the Utilisation of Permanent Magnets in Electrical Apparatus."

WEDNESDAY, APRIL 8..Transport, Institute of, (N. Western Centre), Liverpool. Mr. H. Manock, "The Economic Handling of Goods Traffic at a Terminal Station."

Astronomical Society, Burlington House, Piccadilly, W. 5 p.m.

THURSDAY, APRIL 9..Mechanical Engineers, Institution of, (Glasgow Branch), Royal Technical College, Glasgow. 7.30 p.m. Prof. F. C. Lea, "The Effect of Low and High Temperatures on Materials."

Brewing, Institute of, (Scottish Section), at the Caledonian Station Hotel, Edinburgh. Mr. H. L. Hind, "Alcohol Secretion by Yeast—A Study on Gravities."

FRIDAY, APRIL 10..Metals, Institute of, at the Institute of Marine Engineers, 85, The Minories, E. 7.30 p.m. Mr. C. H. M. Jenkins, "Metals in the Gaseous State."

Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W. 6 p.m.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

No. 3777. VOL. LXXIII.

FRIDAY, APRIL 10, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

THURSDAY, APRIL 16TH, at 4.30 p.m. (Joint Meeting of Dominions and Colonies and Indian Sections). RT. HON. LORD STEVENSON, G.C.M.G., "The British Empire Exhibition." SIR CHARLES CAMPBELL MCLEOD, Bt., will preside. Tea and Coffee will be served in the Library from 3.45 p.m.

SEVENTEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 1ST, 1925. MR. BYRON BRENAN, C.M.G., in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Friese-Greene, Claude Harrison, London.
Logan, Alexander, Calcutta, India.
Lumsden, George James, Freuchie, Fife.

The following candidates were duly elected Fellows of the Society:—

Antaki, Emile, Fallowfield, Manchester.
Clarke, Bertrand R., B.A., New York City, U.S.A.
Goonetilleke, S. A., Wattala, Ceylon.
Lovibond, Mrs. Frances Elizabeth, Salisbury.
Rickerby, John, Gateshead.

A paper on "Siam: its Progress and Possibilities" was read by MR. WILLIAM NUNN, late Adviser to the Siamese Government on Customs and Excise.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

TWELFTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 25TH, 1925.

THE HON. SIR CHARLES A. PARSONS, K.C.B., LL.D., D.Sc., F.R.S., in the Chair.

THE CHAIRMAN, in introducing the reader of the paper, Sir Dugald Clerk, said he was one of the greatest authorities on the internal combustion engine, if not the greatest. He was the inventor of the Clerk cycle in gas engines, now often called two-cycle engines. He remembered hearing Sir Dugald at the Royal Institution forty years ago expounding his views with regard to the stratification of the gases and the air in the cylinders of internal combustion engines. That was claimed as fundamental in the Otto patents, but Sir Dugald held that there was no stratification in gas engine cylinders, a view which had been maintained universally ever since.

The paper read was:—

THE POWER OF INTERNAL COMBUSTION ENGINES FOR MOTOR CARS.

By SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., M.Inst.C.E.

In the year 1923 the total number of power-driven vehicles on the common roads in Great Britain was estimated officially as 1.097 millions; of these 384,000 were motor cars taxed on horse-power and 430,000 were motor cycles. The approximate receipts from cars taxed on horse-power was £5,875,488, an average annual tax of £15.3 per motor car.

All motorists are therefore heavily interested in the official and real horse-power of their motor car engines. From the beginning of motor rating there has been a difference between the two values. In 1906, for example, before official rating appeared, it was usual to describe a car engine as, say, 28-36 h.p. Daimler; this meant that the makers' rating for the engine was 28 h.p., but the maximum power to be obtained was 8 h.p. higher. Inspection of the motor car advertisements in this year, 1925, shows that this system of double rating continues, and we find Rolls-Royce, Delâge and other cars stated as 40/50, although some are mentioned as of one rating, as 40, 21, 12 and so on. It seems on the whole to be considered more attractive by many makers to build engines with an official rating as low as possible compared to the real maximum power of the engine. The "Sunbeam" is stated as 12/30, 14/40, and 20/60, and a Rover is given as 9/20 with the explanatory addition of "Develops well over 20 b.h.p. although taxed at £9 only." The "Vauxhall" gives 14/40, 23/60 and 30/98 h.p., and in the latter case mentions that the engine develops 112 b.h.p. as a maximum. The "Aster" makes matters plain by the statement "20/55 H.P. Tax 20."

If we study these advertisements and consider many brake tests of which full particulars have been published, it is quite evident that the modern engine designer has succeeded in building engines of small cylinder diameter and high piston speed which come under a low Treasury rating, while giving when desired brake powers of easily three to four times the rating. They have, in fact, been able to make powerful engines which are rated at far under their real power output.

When we consider that the total payment of nearly £6,000,000 is made annually by the motorists of our country it is of obvious importance that the tax payments should be equitably distributed among the owners of different cars, and at present of two men owning different cars of the same real power, but quite different rating, the burden may easily be doubled on the owner rated near his true power.

The present system is obviously unjust as between individual car owners, and it is not surprising that recent official cognisance has been taken of the fact.

In the third interim report of the "Departmental Committee on the Taxation and Regulation of Road Vehicles" dated 27th June, 1924, it is stated at section 29, p. 24:

> (29) "The trend of engine design since 1908 has been to increase the stroke bore ratio and to increase the number of revolutions per minute, the latter particularly in recent years. The effect is that, with certain exceptions, the Treasury rating understates the available horsepower of the average present-day type of engine, whereas in the earlier years that rating was a fairly close approximation to the available horse-power. The exceptions though few in type are large in number."

Accordingly the Departmental Committee recommends that a special technical committee be set up by the motor organisations to amend the present method of rating horse-power. (See Sections 53 and 57.)

No technical committee has been formed to deal with this matter, so far as I am aware.

The matter is one of great difficulty and as I have been concerned with motor rating since 1906, first as a member of the judging and expert Committee of the Automobile Club, later the Royal Automobile Club, from 1899 to 1913, then as President of the Institution of Automobile Engineers and Member of the Treasury Committee of 1911 and Chairman of a Joint Committee of the Institution of Automobile Engineers, Royal Automobile Club and Society of Motor Traders and Manufacturers, I am familiar with all the changes which have occurred since 1906. In that year I read a paper entitled "Rating Petrol Engines by Cylinder Dimensions" on 22nd March and I proposed the formula, HP Rating $=\frac{D^2 N}{C}$ in which D is cylinder diameter in inches, N the number of cylinders in the engine and C a constant which was ultimately settled as 2.5. The rating accepted by the Club became known later as the R.A.C. formula.

$$\text{R.A.C. rating} = \frac{D^2 N}{2.5}$$

which was accepted later as the Treasury rating by the request of the Royal Automobile Club.

The matter was further examined and evidence taken by the Treasury Committee of 1911, who reported in 1912. In this report they state that horsepower may be regarded from three points of view, as follows:—

(1) "Brake horse-power or racing horse-power, i.e., the horse-power

developed in a bench test or the horse-power developed by a vehicle driven at the highest possible speed on a good level track " ;

(2) " Touring horse-power, i.e., the average horse-power developed by the engine when the vehicle is run upon give-and-take roads within the legal speed limits " ;

(3) " The average horse-power developed by the engine when the vehicle is run upon give-and-take roads free from speed restrictions."

They considered that the third basis of rating should be taken, and in deciding upon the rating formula they " were guided by the consideration that the expression used should be of a simple character and should involve only quantities which are easily measured." They then accepted the R.A.C. formula already given as combining simplicity with a sufficient measure of accuracy for rating purposes. It is evident that the third rating must give a lower power than the maximum capable of being obtained on the bench. In my view the double value 40/50 or 30/38 or 12/15, that is rating to be 80 per cent. of maximum, legitimately satisfies the intentions of this Treasury Committee, but values like 14/40, 20/60 or 30/98 pass far beyond the limits assigned; for those three engines the rating should be about 32/40, 48/60 and/or 78/98.

In 1906 I fully realised the effect of the rating rule $\frac{D^2 N}{2.5}$ and I stated :—

> " I hope that in the case of the petrol motor, no rigid rules may be formulated, tending to impede progress, and prevent engine designers varying proportions and dimensions of their engines in any way which they may think best adapted to secure improved results.
>
> Personally, I fear it is impossible to devise a rating rule which will enable one to accurately estimate the power of any engine from cylinder dimensions only. To obtain any such accurate rule would require uniformity of mean pressures, cylinder proportions, piston speeds, and engine revolutions, which would tend, in my view, to impede progress rather than assist it.
>
> Before a rule can be framed at all, it is necessary to get accurate information as to the mean pressures produced, the piston speeds used, the total cylinder volumes used, and even the number of revolutions. If we could have standard mean pressures, standard cylinder proportions and piston speeds, then no doubt accuracy would be possible; but the accuracy of this year would assuredly be inaccuracy five years hence, and positive error in ten years."

Tests of engines were made for me and it appeared that a piston speed of 1,000 ft. per min. 90 lbs. per sq. in. on the piston and a mechanical efficiency of 75 per cent. were all average values; values of good engines at the time. The rating rule was obtained from these figures. At the present time a piston speed of 2,000 ft. per min. and over, together with great improvement in mechanical efficiency and actual pressure on the piston produce ηp values of over 100 lbs. per square inch, which are easily maintained, so that three times the R.A.C. rating can now be given for full power without difficulty.

The accuracy of 1906 is totally inapplicable in 1925, so that my warning proved to be correct.

Many attempts have been made to produce a correct rating formula which includes stroke bore ratio, and they have been discussed at the Institution of Automobile Engineers following my 1906 Paper. Among others, F. W. Lanchester, Remington, Henderson, Burls, and Beaumont have made proposals which have not been generally accepted. Prolonged discussion of the matter by the Joint Committee of the Institution of Automobile Engineers, the Royal Automobile Club and the Society of Motor Manufacturers and Traders, and the compilation of tests made upon 143 motor car engines has produced a formula:

Joint Committee H.P. Rating $= 0.45 (d + s) (d - 1.18)$, where d is diameter of the cylinder in inches and s is the stroke in inches, 1.18 is a constant arrived at by the examination of many engine tests.

This Joint Committee adopted the formula on behalf of the three bodies concerned, but the rating was never accepted in practice, although it allowed very fairly for increased piston speeds with high stroke bore ratios.

The original R.A.C. formula remained in use and still continues in practice the only generally adopted expression.

I have recently gone over the mass of papers on rating and endeavoured to find some method of rating which allows complete freedom to designers as to cylinder dimensions and proportions while leaving no room for such extensive evasion as has proved easy with the R.A.C. rating. When a rating rule is made official, designers of engines, steam, gas or petrol, or in another field yacht designers, set to work to find the weak points of the rule. In the case of engines the object of the rating rule is to give a value which determines with some accuracy the power of an engine and hence the tax which engines of certain dimensions must pay. It is the designer's business to build engines which fall well within the rule, but at the same time to provide, if possible, a greater power than that indicated by the rule. I do not blame the designer in any way; he is entitled to build an engine of any power so long as he fulfils certain conditions. In the case of the petrol engine, designers have shown wonderful ability and discovered many facts which have enabled them to produce excellent and very powerful engines at a low rating. This pleases the manufacturer and the motor owner, but it has the undesirable effect of shifting the heavy weight of taxation to other motor owners who are not so fortunate in their choice of engine. I have come to the conclusion that no rating rule depending on cylinder dimensions can be arranged to avoid changing the proportion of taxed power to untaxed power as I have described. But I find a possible solution of the difficulty in the writings of a well-known designer of small diameter cylinder high-speed engines; I refer to Mr. L. H. Pomeroy. In a Paper* read before the Institution of Automobile Engineers in 1912, he states:—

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* P.I.A.E. Vol. VI. p. 82-3.

"In the existing state of design the fundamental dimension of a maximum horsepower equation should be the area of the inlet valve."

In illustration of this he gives figures for seven engines ranging from a 1905 design to a 1912 Brooklands racer; from these figures Table I. has been prepared; the specially large power output realised in the 6th case is attributed by him to refinements in design, workmanship, and lubrication.

TABLE I. 1905-1912 ENGINES CALCULATED FROM POMEROY.

Bore d″	Stroke S″	Dia. Inlet Valve Throat δ″	Throat Area in sq. ins.	Max.BHP Per Cyl.	B.H.P. per sq. in. of Valve Throat Area.
3.62 ins.	3.75 ins.	1.25 ins.	1.23	5.9	4.8
3.35 „	3.94 „	1.5 „	1.77	7.8	4.4
3.35 „	3.94 „	1.5 „	1.77	8.0	4.5
3.54 „	4.73 „	1.625 „	2.08	9.5	4.6
3.54 „	4.73 „	1.6875„	2.24	10.1	4.5
3.54 „	4.73 „	1.75 „	2.41	15.0	6.2
3.54 „	5.75 „	2.0 „	2.86	17.0	5.9

Mr. Pomeroy further discusses the question of values in Vol. VIII. of P.I.A.E. (1914), and on page 408 he observes:—"As a first approximation, the maximum horse-power of all engines with the same valves and gear, will be the same, *irrespective of cylinder size* over a comparatively wide range;" the reason being, of course, that the small engine compensates by a greater revolution speed for what the large engine gains by its increased capacity; in other words, the maximum gas velocity through the inlet valve is substantially the same in all cases at maximum power.

Further, in P.I.A.E. Vol. XIII. (1918-19), pp. 163 et seq., Mr. Pomeroy gives details of a series of tests carried out on two 4-cylinder Vauxhall engines, similar except that "A" had side-by-side valves while in "B" the valves were overhead. The valve area was varied in these tests, values 1.8, 1.4, and 0.7 square inches respectively being tried. In Table II. below, actual maximum power results (obtained at 2,400 r.p.m.) are shown, together with the b.h.p. per sq. in. of valve area for the three valve dimensions tested.

The greater power output with overhead valves will be noted, the disparity increasing as the valve area diminishes. Mr. Pomeroy observes also that in these tests the small valve proved more effective per unit area than the large valve.

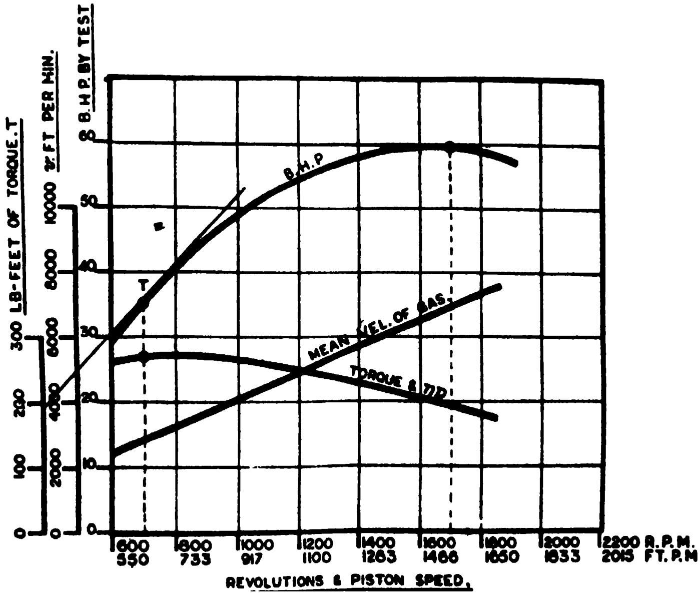
Assume then that a valve area rating is desirable with Mr. Pomeroy, what value of B.H.P. per square inch of inlet valve throat area should be adopted? Table I. giving the results of tests with seven engines of 1905 to 1912 points to 5 B.H.P. per square inch. The lowest H.P. per square inch is 4.4 and the

TABLE II. FROM POMEROY. P.I.A.E. XIII. PP. 163 ET SEQ.

	Maxm. B.H.P. Per Cylinder :—			
Inlet Valve Area, sq. in.	Actual with Engine " A " Valves side by side	Actual with Engine " B " Valves Overhead	B.H.P. per Valve Engine " A "	Sq. in. of Throat Engine " B "
1.8	11.4	12.4	6.3	6.9
1.4	10.7	12.6	7.7	9.0
0.7	6.9	10.1	9.9	14.4

" A " Engine 3.54 ins. Bore, 4.72 ins. Stroke.
" B " Engine 3.54 ins., Bore 4.65 ins. Stroke.

highest 6.2, so that the rated power for those engines would be 12 per cent. above the minimum and 24 per cent. below the maximum value. Many particulars were carefully taken on my behalf by Mr. Burls, of Wolseley, Vauxhall and Lanchester engines described in Clerk and Burls' " Gas Petrol and Oil Engines," Vol. II., from which it appears that at full power bench tests the B.H.P. obtained per square inch of valve throat area was as follows :—Wolseley 3.36, Vauxhall 4.76, another Vauxhall 6.2, and a Lanchester six-cylinder 4.8. The charge velocities were respectively in feet per second 117,



40 H.P. WOLSELEY ENGINE. BORE 5 INS. STROKE 5½ INS.
R.A.C. RATING 40. MAX. B.H.P. 60.

FIG. 1.

112, 137 and 160, and the valve throat diameters were 2.375", 2", 1.75" and 1.56". The maximum B.H.P. on test was: Wolseley 59, Vauxhall 59.8, Vauxhall 60 and Lanchester 55.5. For those four engines a valve area rating of 5 B.H.P. per square inch would be quite suitable; small adjustments of valves and passages would bring all the engines up to that power.

Graphs from those engines are given at Figures 1, 2, 3 and 4 and particulars are marked under each Figure.

In Figure 1 the maximum torque is attained at the low speed of 700 revs. per minute, at which the $\eta\ p$ value is 94.3 lbs. per square inch of piston; the maximum power is attained at 1,700 revs. per minute with an $\eta\ p$ value of 64.7 lbs. per square inch. This engine is of the lower speed type and accordingly the 5 B.H.P. per square inch of inlet throat gives a rating of 88 B.H.P. which cannot be attained without substantial alterations.

A power speed graph of the first Vauxhall engine mentioned is given in Figure 2; graphs of the torque, $\eta\ p$ and mean velocity of gas through valves are also exhibited.

In the accompanying Table III. corresponding values of speed, power, torque and $\eta\ p$ are given.

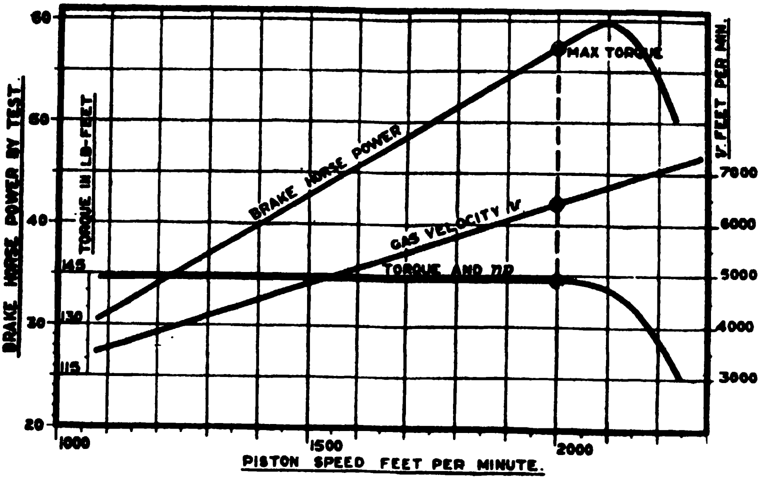
TABLE III.

THE FOUR-CYLINDER, 3.58 ins. x 5.75 ins. VAUXHALL ENGINE.

Piston Speed Ft. per Min.	Revs. Per Min.	B.H.P. by Test.	Torque in lb.-ft.	Lbs. per sq. in.
1092	1140	31.0	142.8	93.2
1250	1300	35.6	143.3	93.5
1500	1570	43.0	144.3	94.2
1750	1825	50.0	143.8	93.8
2000	2090	57.5	144.8	94.4
2100	2190	59.8	143.3	93.5
2250	2350	51.0	114.0	74.4

The power speed graph for this engine is extraordinarily straight, and its direction passes through the zero origin; this straightness results largely from generous proportions of the valves and piping; the gas velocity even at the extremely high piston speed of 2110 ft. per minute has been seen to be only 6,750 ft. per minute. The cylinders accordingly obtain a charge of normal amount at every suction stroke, the brake mean effective pressure and torque remain sensibly constant, and the B.H.P. increases in direct proportion to the speed.

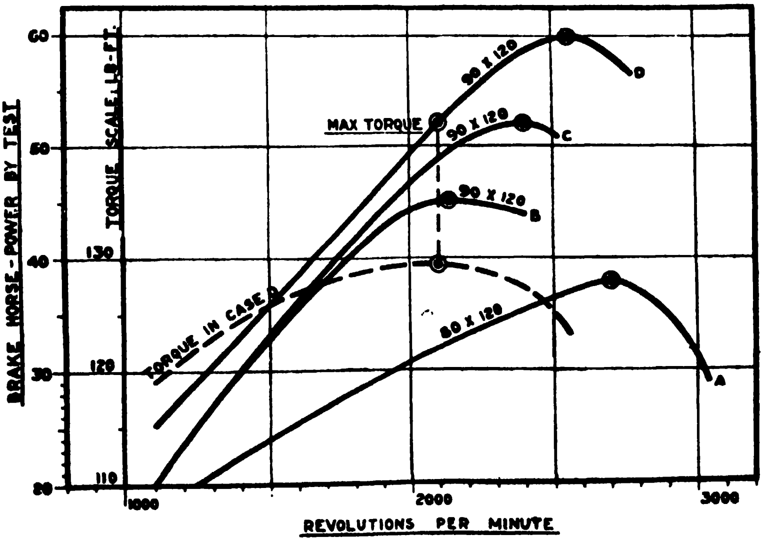
The mechanical efficiency η diminishes with increase of speed, while the mean effective pressure p increases with speed, in the absence of wire-drawing; in this engine the changes in η and p just neutralise one another, the product $\eta\ p$ remaining constant up to the very high piston speed of 2,100 ft. per min.



20H.P VAUXHALL ENCINE BORE 3·58 INS. STROKE 5 75 INS.
RAC RATINC 20·5 MAX. B H.P. 59·8
INLET VALVE RATINC AT 5 H P PER SQ IN. 62 8 B H.P
(NOTE: THIS IS A RACINC ENCINE)

FIG. 2.

Figure 3 shows four power-speed graphs; that marked A was obtained from a Vauxhall engine with cylinders bored out to 80 mm. (3.15 ins.) only. A maximum of 38 B.H.P. occurred at 2,700 revolutions per minute. The



EXPERIMENTAL VAUXHALL ENCINE BORE 3 54 INS. STROKE 4 72 INS.
TESTED AT 3·15 INS BORE AND 3 54 INS. BORE
MAX. B.H.P. 60. SEE TABLE III
INLET VALVE RATINC AT 5 H.P PER. SQ. IN. = 48·2 H.P.

FIG. 3.

compression pressure was, however, deemed to be too low; measured by an Okill gauge the compression pressure was 82 lbs. per sq. in. Curves B, C, and D refer to an engine 90 by 120; the same engine was used in all three cases; the compression pressure, by an Okill gauge at 1,000 r.p.m., had here the value 98 lbs. per sq. in. in each case.

The improvements in speed and power shown by the graphs B, C, and D, were achieved partly by reduction in the mass of the reciprocating parts, partly by carburettor and piping alterations, and partly by improved valve setting; the degree of improvement can be inferred from the following figures:

Case.	Max. B.H.P.	Revs. at Max. H.P.
B	45	2150
C	52	2400
D	60	2550

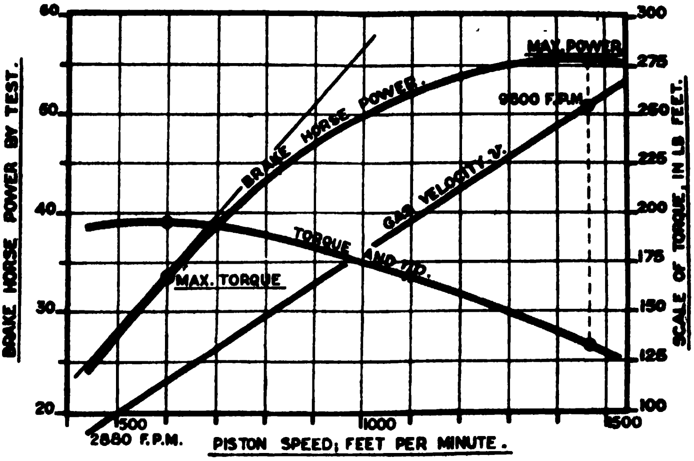
In the appended Table IV. some further results are given; in Case D the valves were $1\frac{3}{4}$ ins. in diameter with $\frac{1}{2}$ in. lift; the mean velocity of gas at different engine speeds has been tabulated for this case.

It will be noted that the values of ηp in case D exceed 100 lbs. per sq. in. between 1,600 and 2,400 r.p.m., and remain remarkably constant; over that range the torque is correspondingly constant; the maximum—so far as one exists—occurs at the very high speed of about 2,100 revolutions per minute, and at 0.87 of the maximum power. The mean velocity of gas through the valve has, at this point, a value of roundly 6,900 ft. per min.

TABLE IV. THE VAUXHALL 90 X 120: EXPERIMENTS IN 1910.

Speed		B.H.P. by Test.			For Case D only.			
Revs. per Min.	Piston Speed F.P.M.	B	C	D	ηp in lbs. per sq. in.	Torque in lb.-ft.	Gas Velo-city, F.P.M.	Remarks.
1100	870	20.0	20.0	25.0	96.5	119.0	3560	
1600	1260	35.3	36.2	38.6	103.0	127.0	5150	
2000	1580	44.3	46.8	49.4	105.0	129.0	6450	
2150	1700	45.0	—	53.2	105.0	129.0	6950	Max. B
2400	1890	44.3	52.0	58.3	103.5	127.5	7720	Max. C
2550	2010	—	—	60.0	100.0	123.0	8200	Max. D

In the 38 H.P. six-cylinder Lanchester engine maximum power is attained at the comparatively low piston speed of 1,465 ft. per min. (See Figure 4), corresponding to a mean velocity through the valve throats of 9,600 ft. per min. This is a rather high value, the usual figure for engines with the ordinary valve arrangements being about 7,000 ft. per min. only; it will be noted that the power graph, Figure 4, soon falls away from the maximum torque line as the speed is increased; greater power could probably be obtained from this engine if desired by increasing the valve throat diameters.



38 H.P. LANCHESTER ENGINE SIX CYLINDER.
R.A.C. RATING 38 4. MAX B H P 55 5 BORE 4 INS. STROKE 4 INS.
INLET VALVE RATING AT 5 H.P. PER SQ. IN — 57·6 H.P.

FIG. 4.

The power speed graph is shown in Figure 4 together with curves of torque, $\eta\ p$ and gas velocity, and the accompanying Table V. exhibits numerical values of the torque and $\eta\ p$ over the range of speeds tested.

TABLE V. LANCHESTER SIX-CYLINDER. 38 H.-P.

Revs. Per Min.	O. Ft.per Min.	B.H.P. By Test	[illegible] in Lb.-Ft.	[illegible] Lbs. Per Sq. In.	Notes.
660	440	24.2	192.5	96.2	
900	600	33.6	196.0	98.0	Max. Torque
1200	800	43.0	188.5	94.2	
1500	1000	49.6	173.5	86.8	
1800	1200	53.6	156.5	78.2	
2200	1467	55.5	132.6	66.3	Max. Power

It will be noted that maximum torque occurs at the low speed of 900 revolutions, while maximum power is not attained until the speed has increased to 2,200 revolutions per minute, at which the value of $\eta\ p$ is only 66.3 lbs. per sq. in. The normal full speed is considered to be 1,400 revolutions per minute, at which the B.H.P. is 48, $\eta\ p$ is about 89½ lbs. per sq. in., and the gas velocity through the valves is 6,100 ft. per min.

Table VI. gives such particulars as I have been able to obtain of ten 1924 engines of varying R.A.C. ratings which I shall now discuss.

TABLE VI.

COMPARISON OF INLET VALVE THROAT AREA RATING 1 SQ. IN. = 5 B.H.P. WITH R. A. C. RATING, AND MAXIMUM B.H.P. ON TEST BENCH. CALCULATED FROM PARTICULARS OBTAINED OF 1924 ENGINES.

Name	1 No. of Cylinders.	2 R.A.C. H.P.	3 H.P. by Inlet Valve Throat Area 1 sq. in. = 5H.P.	4 Max.B.H.P by Bench Test.	5 Inlet Valve Throat Dia. in ins.	6 Ratio Valve Throat Dia. to Bore	7 Bore × Stroke inches	8 Valves Overhead =O Valves Side-by-Side=SS.	9 Piston Speed in Ft. per min. at Max. Power.
A.C. 12 ..	4	12.0	24.6		1.25″	0.46	2.7″×3.9″	S.S.	
Ford.	4	22.5	26.6	20	1.3″	0.35	3.75″×4″	S.S.	1066
Lanchester 40	6	38.4	84.0	76 ?	1.89″	0.47	4″×5″	O	
Lanchester 21	6	21.0	40.0		1.3″	0.44	2.93″×4.5″	O	
Morris Cowley 12	4	11.9	39.0	22.5	1.57″	0.58	2.7″×4″	S.S.	1906
Morris Oxford 14/28 ..	4	13.9	39.0	28 ?	1.57″	0.53	2.95″×4″	S.S.	
Riley 11/40 ..	4	10.8	30.0	38.5	1.38″	0.53	2.39″×4.34″	S.S.	
Rover 14/45 ..	4	13.9	39.0		1.57″	0.53	2.9″×5.1″	O	2315
Vauxhall 14/40	4	13.9	30.0	43	1.38″	0.47	2.9″×5.1″	S.S.	2210
Wolseley 11/22	4	10.5	30.0		1.38″	.054	2.5″×3.7″	O	

NOTE.—Inlet Throat Velocity on Assumption of no Pressure Fall during Charging Stroke

$$= \frac{\text{Piston Speed in Ft. per minute.}}{\text{Ratio of Valve Throat Dia.}^2 \text{ to Bore}^2.}$$

Calculated in this way the Inlet Throat Velocities for the Four Cars of which the Data have been obtained are as follows:—

FORD = 159 ft. per sec.

RILEY = 149 ft. per sec.

MORRIS COWLEY = 96 ft. per sec.

VAUXHALL = 167 ft. per sec.

It will be seen from Table VI. that in the three cases, Riley, Rover and Vauxhall, where the double ratings advertised are 11/40, 14/45, and 14/40 respectively, the valve throat area rating of 5 B.H.P. per square inch gives 30, 39, and 30 respectively, or almost 80 per cent. of advertised maximum power. The value 5 B.H.P. per square inch here gives the margin of spare power intended by the 1911 Treasury Committee. In the cases of A.C., Lanchester 21 and Lanchester 40 the inlet valve area rating is roughly double that of the present R.A.C. rating, while with the Wolseley, Morris Cowley and Morris Oxford the inlet valve area rating is roughly three times the R.A.C. rating and the B.H.P. given by these engines at present is somewhat under the new rating. In these three engines, however, ratio of inlet valve throat diameter is high—in every case more than half the cylinder diameter and the effect of valve area rating would soon bring up the piston speeds to obtain higher power or reduce valve diameters to get the lower power at present given. This is also true of the A.C. and the two Lanchesters. The proposed rating in the case of the Ford is about 4 B.H.P. higher than the R.A.C. More power could be obtained from the Ford if desired; at present the piston speed is low. I have confidence that present engine practice would speedily adjust itself to such a rating if adopted.

How long, however, would the designers be content with a rating within 80 per cent. of maximum power? They would doubtless attempt to get much greater power within the rating rule.

In what direction would they find a way out? Mr. Pomeroy has shown us the way to get outside of the inlet valve rating in the interesting and valuable experiments summarised in Table II. He tested two similar engines: (A) Valves side by side and (B) Valves overhead; both at 2,400 revs. per minute. He arranged inlet valves of 1.8, 1.4 and 0.7 square inches area and ran successive tests with each area. He found two important facts: (1) As valve area diminished B.H.P. obtained per square inch of area increased; (2) Valve overhead engine gave greatly increased power per square inlet area as compared with side-by-side valves.

With valves side by side, Engine A, with the three valves of 1.8 sq. in., 1.4 sq. in., and 0.7 sq. in., the B.H.P. per square inch of valve area was 6.3, 7.7, and 9.9 respectively, and with the valves overhead, Engine B, the corresponding values were 6.9, 9, and 14.4 B.H.P. per sq. in.

Accordingly attempts would doubtless be made to use very small valves in both side-by-side and overhead engines. It is probable that in the side-by-side engine the fall of power at 2,400 revs. from 11.4 to 6.9 B.H.P. per cylinder would reduce power per cylinder too much, but with valves overhead the similar power fall is only from 12.4 to 10.1 H.P. per cylinder, while the rise of power per square inch is from 6.9 B.H.P. to 14.4 B.H.P.; the power per square inch is doubled.

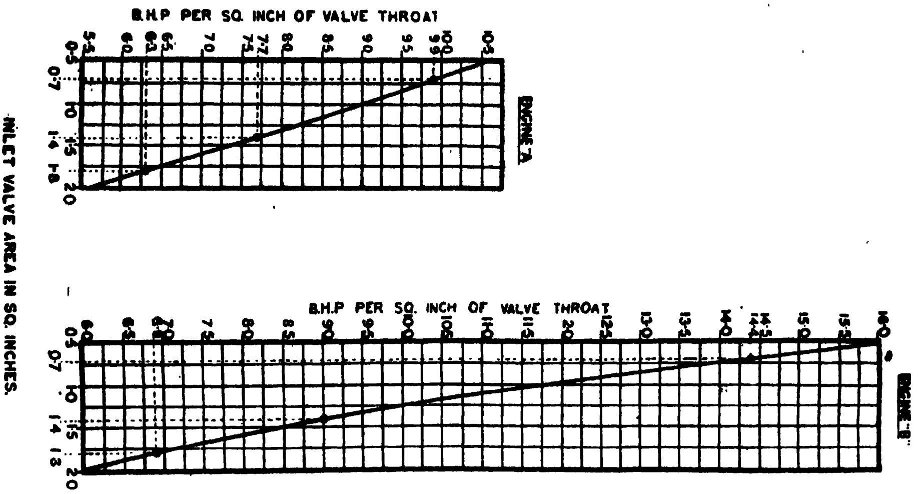


FIG. 5.

This difficulty can be met by plotting the results obtained with engines A and B, valve throat areas against B.H.P. as shown at Fig. 5. With engines of type A, a valve of 2 sq. in. area would give 5.6 B.H.P. per square inch inlet valve area, and one of 1.25 sq. in. would give 8.2 B.H.P. per sq. in. With engines of type B a valve of 2 sq. in. area would give 6 B.H.P. per sq. in., and 1.25 sq. in. a brake power of 10 horse per sq. in. Tables could be compiled for the two types, A, valves side-by-side, and B, valves overhead, including all valve areas in use, so that the B.H.P. per square inch would be shown at once on inspection. The true H.P. of the engine could then be obtained in the simplest way. Such an arrangement would make it impossible for the engine rating to stray far from the power or fraction of power really developed by any particular engine.

To enable this to be done it will be necessary to make further tests on a small number of engines at speeds of revolution varying from 1,000 to 2,500 per minute with engines having side-by-side and overhead valves with valves varying from 3.5 sq. in. to 1 sq. in. area. It would then be easy to deduce the law of change just discussed. At present the experiments are too few to determine an accurate rating rule. If the Treasury wish this investigation to be carried out it would be well to have the determinations made at the National Physical Laboratory, in order to overcome prejudice in the general public against private tests by manufacturing firms.

Assume this to be done and B.H.P. constant or constants settled; assume for simplicity that the constant is five, then, as that constant will give a total taxable H.P. about double that given by the R.A.C. rating more equitably divided between the different makers' engines, it will be necessary for the Treasury to lower the payment per horse power to about one half, that is, to ten shillings per H.P. instead of £1. This could be adjusted to produce the six million pounds at present required by the Treasury. The incidence of the tax would then fall as nearly as possible proportional to the true power of the engines used by each motor car owner.

A rating such as is here suggested carried out as discussed in this Paper would leave the designer unlimited freedom of choice as to cylinder dimensions and stroke bore ratios; it would leave the piston speed also quite open; some designers would wish for lower piston speeds and larger cylinders—they have their advantages—and the only limit imposed would be that of valve area. In my opinion engines would be rapidly improved, because of the increased power of variation possible.

Mr. A. E. Berriman has read an excellent Paper entitled "A Review of the Rating Question," in which he discusses all the cylinder and stroke dimensions rules proposed since 1906, and I recommend those who wish to study the development of the Rating Rules to read the Paper in the Proceedings of The Institution of Automobile Engineers. Mr. Berriman develops the case for taxation of petrol. I do not here deal with that matter. I assume that the Treasury propose to continue power rating in some form.

DISCUSSION.

The Chairman suggested a slight elaboration of the author's idea that the rating of an engine should depend on the amount of combustible mixture it took in. The constriction through the inlet valves regulated that within certain limits, but possibly the idea could be carried further, and an automatic apparatus made which would prevent more than a certain quantity of mixture going in per minute or per second. The adoption of such an arrangement, the nature of which he demonstrated by means of a diagram (see Fig. 6), would leave the engine designer free to design his engine in accordance with his own or his customer's requirements; he could supply a slow-running engine with comparatively small valves, an engine which would be very durable, or a fast-running engine like an aeroplane engine,

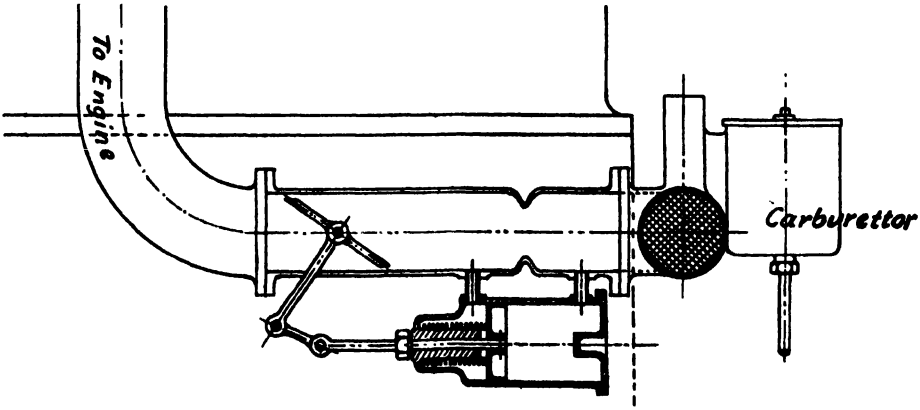


Fig. 6.

with a very short life and heavy upkeep charges. The apparatus could be locked up, if required, like a taximeter on a cab, and could be inspected by Government Inspectors and calibrated at intervals.

Lieut.-Colonel Mervyn O'Gorman, C.B., said he had had the privilege of hearing, many years ago, the paper in which the author suggested the old D^2 rating, which, though not popular at first, eventually roused great enthusiasm. It was with some surprise that he now heard him propose Mr. Pomeroy's rating, because the arguments put forward in the paper by no means clinched the question of the advisability of using the valve throat as a rating basis. The Vauxhall experiments did not indicate clearly that the valve throat formed a particularly useful rating basis. It was clear that the size of a hole bore some relation to the quantity of gas which could pass through it in a given time, but that also depended on other factors, notably the shape of the inlet pipes, and so on (which would, to a certain extent, be common to most petrol engines), and would be affected by anything which permitted a complete modification in the shape of the hole, like a sleeve-valve. Even though the sleeve-valve, double or single, was an admirable device, he did not suppose the author would advocate anything which exercised a financial pressure in favour of it. Personally, he thought a pipe which finished with a maximum delivery nozzle would deliver more gas per second than one the end of which was obturated to a certain extent, and which finished with an annular opening without a stream-line body, like a poppet valve.

Such a rating as the author now suggested would, he thought, exercise a definite pressure in the direction of using sleeve-valve engines, and engines with that kind of diminished orifice which was called a maximum delivery orifice. It would also give rise to a tendency to produce large cylinders, as one of the diagrams showed particularly clearly, *i.e.*, large cylinders for the valves. If a man were going to pay £20 a year because his valve was a certain size, he would see he got as good value for that £20 as possible, and to do that would employ big cylinders. The effect on construction might only be after a lapse of time; it would take a year or so before it was felt; but it would induce a man to employ big cylinders, sleeve-valves and a particular type of nozzle, and, though those things might be good in themselves, they would be adopted, not in order to secure the best design, but through the influence of the rating.

The author would no doubt give further explanations before he could be said to have made good his case. Personally, he was prejudiced against any change in rating methods, because when the basis on which taxation was imposed was altered, it was probable that the total amount collected from the motoring community would be increased. Motorists represented only a small fraction of the total electorate, and would, therefore, be unable to resist such an imposition.

As an expression of a fraction of the maximum power of the engine, the rating proposed by the author would often be better than the R.A.C. rating, which he did not think was notably good from that point of view at the present time. As far as taxation was concerned, however, it should be remembered that the paper mentioned three kinds of horse-power on which the motorist might be taxed: a maximum horse-power, the horse-power an engine could develop at unlimited speed on English roads, and the horse-power it developed with legal limit speed on English roads. The author considered the third as the most reasonable. Taking the case of a man who drove at reasonable speeds, not observing the law when it was absurd, such a man would drive from London to Brighton at an average of 2 m.p.h., and with a Rolls of 55 cwt. would average 24 or 27 h.p., or with a Ford about 7 h.p.

If one considered how very variable was the use to which motor cars were put, he thought it would be agreed that no increase in the accuracy of the technical value of the rating basis would improve the justice of the incidence of the tax. It would be better to leave the rating alone. No one imagined the R.A.C. rating represented the maximum horse-power, but everyone knew it was what the tax was paid on.

PROFESSOR W. E. DALBY, F.R.S., said the general feeling of motor car owners was that the present system of taxation was unjust to all except lorry owners. The basis of present day taxation was utterly wrong; it ought to be based on the extent to which the vehicle used the roads, and the damage it did to them. He thought it might be possible to go a step further in developing the Chairman's suggestion. The Chairman had suggested an instrument by which the charge going in could be regulated. Why not go a step further and make the instrument integrate the total amount of charge used per annum, and then base the tax on that? That would be more just than taxation based on a mere dimension. The Treasury now rated a motor car at £1 per horse power, reckoning the horse power on the arbitrary expression $\frac{d^2n}{2.5}$. This formula was largely due to Sir Dugald Clerk, and the speaker gathered from his most interesting lecture that he now suggested a modification of the formula, to bring the H.P. more nearly to the actual H.P. available, with present-day engines. Makers had improved the design and increased the piston speed so that the Treasury rating now bore little relation to the actual H.P. developed at normal car speeds. The author based his suggestion on his analysis of the data which he had brought before them. The speaker received the paper only on his entry into the room, so that he had not been able to study the figures to see how far he could support them from his own experiments.

Any formula which aimed at giving the H.P. of a motor must be an arbitrary one, because the power itself was not constant; over the range at which the engine usually worked the power was nearly proportional to the speed at full throttle. Therefore any formula applied only to one set of conditions of the infinite sets of conditions in which the engine was run in practice.

The R.A.C. formula even as it stood was very useful. It was based on a piston speed of 1000 ft. per min. and 67 pounds mean pressure on the brake.

After many years' experience of testing petrol engines on the bench, he found that, through quite a large range of engines and makes, if one ran the engine at a piston speed corresponding to 1,000 feet per minute, one ought to measure on the brake the R.A.C. rating. If one did not measure it, one could assume the engine was not as good as it might be; but one rarely measured more. He had never tested an engine at 1,000 feet piston speed which gave more than the R.A.C. rating.

The modern high speed engine, however, developed more than the Treasury rating To quote an extreme case by way of illustration, a 6 cylinder engine with cylinders 6½ inches in diameter would be taxed on 101 H.P. But the actual H.P. for which it was designed and which it developed continuously, was over 300. The reason was that its piston speed was 1600 feet per minute instead of 1000, and it developed a mean effective pressure at the break of 117 lbs. per sq. inch instead of 67.2 lbs. per sq. inch. This illustrated the trend of the modern motor car engine, though the engine itself was an aircraft engine.

The author aimed at spreading the burden of taxation more justly, so that those who used high powers paid in proportion. The speaker was sure they were all in cordial agreement with the author. Before entirely agreeing that the method suggested would meet the case he would like time to study the interesting figures the author had brought together. Quite apart from the merit of the question, and from the scientific aspect of the paper before them, he could not help sharing with Colonel O'Gorman a fear that any change in the present method of rating would be seized by the authorities as an excuse to make them pay more.

He congratulated the author on an interesting and valuable paper, and was sure that all would feel grateful for the very useful data he had collected, analysed, and discussed that evening.

VISCOUNT FALMOUTH said that, in view of the feeling at present prevailing in Parliament and amongst ratepayers generally, he thought it would be better to leave the question of rating alone until the Treasury made some move in the matter. He was certain that any change would involve additional taxation on motorists.

DR. W. R. ORMANDY said the attitude taken by previous speakers in regard to any alteration in the method of rating would be endorsed by motor manufacturers and users generally. The author had assumed that the Treasury would not consider basing taxation on the fuel used. The absurdity of the present method was so obvious that any change brought about by an alteration in the method of rating would be of negligible advantage. Personally, he failed to see why the difficulties in the way of taxing fuel were insuperable. If, however, there must be taxation by general rating, the consensus of opinion amongst members of the Institution of Automobile Engineers was that the present rating should be left alone; any alteration would lead to as great, if not greater, injustices in some other direction, and the Treasury, to be on the safe side, would impose a tax which would bring them in more than before.

It had been stated that the English automobile manufacturing industry had been injured by the R.A.C. rating. It had, however, led manufacturers to make cars with higher piston speeds, thus leading to greater fuel economy, and any alteration which, in order to defeat a tax, led to lesser fuel economy, would be a movement in the wrong direction. Whatever the situation might be at the present time with regard to fuel, the tendency was for consumption to increase more rapidly than production, and, therefore, the effect of any alteration in rating on fuel consumption should be taken into consideration.

It was also interesting, in that connexion, to watch the trend of affairs in America, which produced so many more cars than this country that our production was a negligible factor in regard to fuel consumption. The tendency in America was to make engines with smaller cylinders, higher piston speeds and higher compressions; Americans had come to the conclusion that the English system of making really efficient engines was worth imitating. While that was partly brought about by the desire to make engines which would suit the foreign market, it was also due to the desire for fuel economy, because the price of fuel in that country tended to rise.

MR. L. A. LEGROS said it was difficult for any one who had not access to the figures to know how the money raised by the tax on motorists was distributed, and to what extent the tax had contributed to injuring the trade of British manufacturers abroad. There could be no doubt that the sales of British cars in the colonies had fallen off considerably; one correspondent in Australia had told him that he could sell fifty American cars to one British, because the former met the requirements of the country while the latter did not. He believed the rating formula had largely contributed to that state of affairs. The "woolly" engine would enable one to get out of a difficult place more easily, and it was an easier engine for a novice or a man away from civilisation to handle than the high compression engine. If there were to be a reversion to the earlier "woolly" engine, however, it would have to be accompanied by a tax on petrol, so as to encourage the evolution of the engine in the direction of increased economy in petrol.

Mr. A. E. Parnacott asked the author where he measured the area of the throat of the valve. If the area were taken across the seat of the valve, a larger volume of mixture could be passed through that dimension by making the valve inlets, when opened, the equivalent of a Vena contracta and expansion cone. He himself had been in the habit, for racing purposes, of preparing engines by approximating to that arrangement. If the author's throat measurement were introduced, valves would tend to take a stream line form so as to get a small measurement on the throat and thus avoid taxation.

The ratings of an engine as to the actual horse-power were, he thought, unimportant. An engine was driven more or less continuously on the throttle. Roughly, the horse-power of an engine was about 1 h.p. for every 100 cu. cms. static dimension of the engine cylinders. That was a more correct estimate than could be obtained by the author's throat measurement. It was usual to provide 1 cwt. of weight for every 100 cu. cms. of the engine. If, therefore, the formula he suggested approximated to the horse-power, and also to the weight of the vehicle in hundredweights, it might be possible to weigh the vehicle and tax it by weight—so much per cwt. If the weight basis were introduced, it would leave the designer free to meet American competition, and it would put a premium on the lighter type of car. After a few years of taxation on such a basis, British vehicles would become more suited to overseas colonial conditions.

Most ratings, when one considered two-stroke engines and compressors for four-stroke engines, seemed to fail. Compressors were coming in for four-stroke engines for forcing an additional charge into the cylinders, and he thought it would not be long before the compressor, used for two-stroke engines, would wipe out the valves. There would then be no valve throat to measure.

Mr. J. Ronca said the author had shown several tabular statements indicating that, within a variation of about 60 per cent., he got 5 h.p. per square inch of effective valve opening. Those figures had been obtained with what might be called ordinary engines; he would like corresponding figures for engines operating with super-compression or super-charging.

Mr. R. À-Ababrelton, speaking as a ratepayer and a house-owner, hoped that when any change in the method of rating was made, care would be taken to see that the heavy motor lorry paid its proper share. The damage done by such lorries was immense.

Mr. A. F. Evans said he had ascertained that, on the present basis of taxation, a Mark V Tank with a 6-inch howitzer behind it would pay twice as much as a Ford car. He suggested that if one took the piston displacement of the engine in travelling a given distance with the gear box set in direct drive, one would get the ratio of gear and engine size and revolutions—in fact, a better approximation to horse-power than by any arbitrary arrangement of cylinder dimensions without revolutions or gear. If one could add to that the weight of the fully-laden vehicle and apply a constant, a more equitable rating basis would be obtained. The measuring of the inlet orifice could be readily overcome by extending the orifice into a venturia. It would be more equitable to take the area of the jet than the area of the inlet port.

SIR DUGALD CLERK, in reply, said he agreed with Colonel O'Gorman that the case he made out in the paper for a change in the method of rating was not complete, but he thought, nevertheless, that by some such method as he suggested it would be possible to get a much closer approximation to the real power than with the D_1^2 or any other cylinder dimension rule. He did not propose that the new method should be applied at once; he had stated that a good deal of investigation was necessary.

The cubic capacity rating was quite inaccurate; it assumed that an engine would give a piston speed proportional to its stroke, and that was not the case.

Professor Dalby favoured a tax on fuel. Personally, he thought that if it were carried out efficiently, and without too much red tape, the fuel tax would provide a fairer basis than any cylinder rating, because it would take total mileage into account. If one consumed a certain number of gallons per annum, and took the number of horse-power one could get out of each cubic centimetre of fuel, one would have a very fair idea of the total horse-power one's car had used during the year. Both the trade and the R.A.C. differed very strongly from the findings of the Departmental Committee which dealt with the subject. They favoured the cubic capacity idea, but had been given to understand that the Treasury would not accept a rating which was more untrue than the present one, which was the case with the volume rating.

If the Treasury were given a value which had some connexion with the actual power of the engine, and if there were little possibility of evading it, they would probably agree to adjust the rate per horse-power. Personally, he would advocate a fuel tax if he saw any possibility of its being adopted; but there was none.

Professor Dalby also suggested that the Chairman's arrangement might be integrated. That would be very useful, and be another way of getting a yearly record of the horse-power; but he feared the integrating arrangements would be rather more complicated than the Chairman's original apparatus. It would be a good idea if it could be carried out.

He agreed that an engine running at a piston speed of 1,000 feet per minute would always give about the R.A.C. rating. That was the piston speed experimented on in 1906, and was a very usual one; but one could not bind the makers down to it, and if smooth running was obtained with a speed of 2,000 feet no one would object to the higher speed, which was, in fact, quite common at the present time. Personally, he would be strongly against altering the motor rating; he was in favour of keeping it as it was, and altering the factor with regard to it, but the trade had only themselves to blame when they advertised their cars as 14/40, 30/98 and so on, and boasted about the power their engines developed which did not have to be paid for.

He appreciated Dr. Ormandy's point about the consumption of petrol increasing more rapidly than the output. It was a serious matter, and one which he himself had been pressing in connexion with the general use of oil instead of coal. If the process continued the world's supply of oil might soon become exhausted but there was a natural remedy—the economic remedy; the price would rise.

He did not see why motor taxation should cause loss of trade. He understood

American motors differed in some respects from those made in this country, and were designed to make a more efficient use of rougher roads, and so on. He did not think motor rating causing the building of long-stroke engines had much effect there.

Mr. Ronca mentioned super-compression. During the last twenty years he had made many experiments in super-compression. He did not think there was the least likelihood of a very large extension of super-compression for internal combustion engines of motor cars, except perhaps for racing purposes.

Mr. Evans spoke of piston displacement. He had drafted a proposal for a rating on that basis during the past few months. Such a rating meant fixing the piston speed; if one could have a fixed piston speed there would be no difficulty about it. One could get a very fair rating if one could get the piston speed, but one could not get it from a dimension, and the R.A.C. were asked to produce a rating depending only on dimensions.

THE CHAIRMAN, in proposing a hearty vote of thanks to Sir Dugald Clerk for his paper, said it might be suggested that rating should not be based entirely on horse-power, in the sense of being exactly proportional to it, but should go up in the same way as super-tax. Large cars were a luxury, and he suggested that for horse-powers of 15 or over the tax should rise as the square of the horse-power, or in some such way. Not only were large cars a luxury, but they were a greater danger to the public, and they wore out the roads more rapidly.

The vote of thanks was carried unanimously, and the meeting then terminated.

GENERAL NOTE.

ROYAL MICROSCOPICAL SOCIETY.—The Council of the Royal Microscopical Society have accepted an invitation to hold a conference at Sheffield on April 20th, 21st and 22nd. Important papers will be read and discussed, and receptions given by the Lord Mayor of Sheffield, the Vice-Chancellor of the University and the Master Cutler. There will be a Trade Exhibition and the arrangements also include visits to the works of leading firms. Sir Robert A. Hadfield, Bt., F.R.S., and Mr. A. Chaston Chapman, F.R.S., have been appointed delegates for the Royal Society of Arts.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock :—

APRIL 22.—CEDRIC CHIVERS, J.P., Mayor of Bath, "Bookbinding." EMERY WALKER, F.S.A., will preside.

APRIL 29.—ANDREW BALFOUR, C.B., C.M.G., M.D. (Edin.) B.Sc., D.P.H., F.R.C.P.E., "The Trend of Modern Hygiene." SIR GEORGE NEWMAN, K.C.B., M.D., D.C.L., F.R.C.P., Chief Medical Officer, Ministry of Health, will preside.

MAY 6.—AIR VICE-MARSHAL SIR WILLIAM SEFTON BRANCKER, K.C.B., A.F.C., Director of Civil Aviation, Air Ministry, "Commercial Aviation." HIS GRACE THE DUKE OF SUTHERLAND, President of the Air League of the British Empire, will preside.

May 13.—(Joint Meeting of the Royal Society of Arts, the Royal Aeronautical Society, and the Anglo-Batavian Society.) Thomassen à Thuessink van der Hoop, "The Flight to the Netherlands East Indies." (The paper will be read in English). Air Vice-Marshal Sir William Sefton Brancker, K.C.B., A.F.C., will preside.

May 20.—Professor John Ambrose Fleming, M.A., D.Sc., F.R.S., "William Sturgeon and the Centenary of the Electro-magnet." Alan A. Campbell Swinton, F.R.S., late Chairman of the Council of the Society, will preside.

Indian Section.

Friday afternoons, at 4.30 o'clock.

May 8.—Sir Gilbert T. Walker, C.S.I., M.A., F.R.A.S., Sc.D., Ph.D., F.R.S., "Indian Meteorology."

May 22.—Sir Alfred Chatterton, C.I.E., B.Sc., Assoc.M.Inst.C.E., "The Industrial Progress of the Mysore State."

June 12.—Brigadier-General Sir Percy M. Sykes, K.C.I.E,, C.B., C.M.G., "The Heart of Asia and the Roof of the World."

Dominions and Colonies Section.

Thursday afternoon, at 4.30 o'clock:—

June 18.—Hon. W. G. A. Ormsby-Gore, M.P., Under Secretary of State for the Colonies, "East Africa."

Dominions and Colonies and Indian Sections. (Joint Meeting.)

Thursday afternoon, at 4.30 o'clock:—

April 16.—The Rt. Hon. Lord Stevenson, G.C.M.G., "The British Empire Exhibition," Sir Charles Campbell McLeod, Bt., will preside.

Howard Lectures.

Monday evenings, at 8 o'clock:—

Professor John Samuel Strafford Brame, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, "Motor Fuels." Three Lectures. April 20, 27, May 4.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

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Tuesday, April 14..Transport, Institute of, (Students' Society), at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C. Mr. H. G. Scott, "Station Accounts and Returns in Relation to the Final Balance Sheet of a Railway Company."

Electrical Engineers, Institution of, (E. Midlands Sub-Centre), at the College, Loughborough. 6.45 p.m. Discussion on "Justifiable Small Power Plants."

Wednesday, April 15..Embroiderers' Guild, 74, Grosvenor Street, W. 6 p.m. Dr. Sibyl Welsh, "Stitchery in Relation to Design."

Electrical Engineers, Institution of, (Sub-Centre), at the Royal Victoria Hotel, Sheffield. 7.30 p.m. Dr. F. S. Goucher, "The Strength of Metals at High Temperatures."

Thursday, April 16..Mechanical Engineers, Institution of, (Midland Section), at the Queen's Hotel, Birmingham 6.30 p.m. Messrs. W. B. Lewis and G. S. Irving, "The Scientific Treatment of Boiler Feed-Water, introducing the Colloidal Aspect."

Friday, April 17..London Society, at the Royal Society of Arts, John Street, Adelphi, W.C. 5 p.m. Air Vice-Marshal Sir William Sefton Brancker, "Impressions of London from the Air."

Engineers, Junior Institution of, 39, Victoria Street, S.W. 7.30 p.m.

Sanitary Institute, at the Medical Baths, Torquay. 7.30 p.m. Discussions on 1. "The Desirability of a New Public Health Act." 2. "The Town Planning and Housing Problems at Torquay." 3 "The Spa Treatments of the Medicinal Baths, Torquay." 4. "Maternal Mortality."

Central Asian Society, at the Royal United Service Institution, Whitehall, S.W. 5 p.m.

Photographic Society, 35, Russell Square, W.C. 7 p.m. Dr. H. D'Arcy Power, "The Reproduction of Colour and Tone."

Saturday, April 18..Sanitary Institute, at the Medical Baths, Torquay. 10 a.m. Discussions continued.

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FRIDAY, APRIL 17, 1925.

***All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.* (2.)**

NOTICES.

NEXT WEEK.

MONDAY, APRIL 20th, at 8 p.m. (Howard Lecture.) PROFESSOR JOHN SAMUEL STRAFFORD BRAME, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, " Motor Fuels." (Lecture I.)

WEDNESDAY, APRIL 22nd, at 8 p.m. (Ordinary Meeting.) CEDRIC CHIVERS, J.P., Mayor of Bath, " Bookbinding." EMERY WALKER, F.S.A., will preside.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, MARCH 6TH, 1925.

THE RT. HON. VISCOUNT CHELMSFORD, G.C.S.I., G.C.M.G., G.C.I.E., G.B.E., in the Chair.

THE CHAIRMAN said no one was more qualified to deal with the subject under discussion that evening than Sir Henry Sharp, who joined the Educational Service in 1894, and had only recently left it. For some 12 years Sir Henry held a very responsible position at the headquarters of the Government of India, and had been responsible for most of the University Acts of the last 10 or 15 years. What he did not know about Indian universities was not worth knowing. He had not finished his educational labours, but was at present Secretary of the Oxford University Commission, and was working very hard in that capacity. Personally, he (the Chairman), not only as Sir Henry's late Chief in India, but also at the present time, was deeply indebted to him for the extraordinary industry and energy he was putting into his work as Secretary of the Oxford University Commission.

The paper read was :—

THE DEVELOPMENT OF INDIAN UNIVERSITIES.

BY SIR HENRY SHARP, C.S.I., C.I.E., M.A.

The University in India is an affair not only of educational, but also of economic and political interest. It is a cause of self-congratulation to the

Government as a whole, of some anxiety to the guardians of the public purse and of deep distrust to those who see nothing but disaster in the extension of learning. Its buildings serve as a prominent adornment for the cities, its councils as a convenient platform for the budding politician and its organisation as a subject of keen debate for the legislatures. Above all, it is the pride and darling of the middle class. The lad of this class in Bengal learns from his cradle to look towards the Senate House of Calcutta as a Mecca which will secure him his passport to Paradise. Paradise may mean in the end a thriving practice in law or medicine, a High Court Judgeship or a responsible post in the administration of the country. Or it may mean a clerkship of £40 a year. Any-way it means something, presents endless possibilities and is intensely alluring. Hence the University has attained surprising popularity. In 1914, Bengal, with a population equal to that of the United Kingdom, contained likewise an equal number of University students. There are at the present moment sixteen Indian Universities, 253 constituent or affiliated Colleges or departments, 4,393 professors and teachers and nearly 67,000 students. The object of this paper is briefly to trace the growth of these institutions.

If there are any who think that the history of Universities in India, whatever else it may be, is at least short, extending over a period of less than seventy-years, they are doomed to disappointment. For in truth the story extends over some twenty-four centuries. Ancient and mediæval India had its University institutions; and, though the ideals of those times differ from the ideals of to-day, and though the main object of this paper is the development of the modern University, it is necessary to speak, however briefly, of those institutions.

The narrative falls into five clearly defined chapters. The first and in time far the longest chapter is that which tells of the old indigenous institutions. The second deals with the inchoate beginnings of a modern system. The third is ushered in by the famous despatch of 1854 and tells of the five original affiliating Universities of India. During this period there was a Commission on Indian Education in 1882-83. But the Universities were excluded from its terms of reference; so it is unnecessary to refer to it. The fourth commences with Lord Curzon's Universities Commission of 1902 and describes the attempt then made to reform a system which in the opinion of many had already outlived its day. The fifth begins with the Government of India's Resolution of 1913, which, enforced by the findings of the Commission of 1917-19 on the Calcutta University, initiated a new and striking epoch in the history of Indian Universities.

The beginnings are lost in the mists of antiquity. The Mahabharata and the Jatakas make mention of Taxila as a great centre of Vedic and afterwards of Buddhist learning, even before the invasion of Alexander. To that centre princes and Brahmans sent their sons for education. The monasteries of Taxila were devastated and burned by invaders. Other seats of learning arose, among which Nalanda attained to special fame. Hiuen-Tsang, the Chinese pilgrim, has left the following account of this monastery as he saw it in the first half of the seventh century A.D. " The monks, to the number of several thousands, possessed every distinguished talent and a mass of knowledge. Among them were several hundreds who by their capability earned fame among their contemporaries and whose reputation was borne even to other countries. . . . . Those who required lessons and who discussed deep problems never found the days long enough. From morn to eve they provided each other with information ; young and old united in bringing each other to perfection. If any were incapable of discussing the mysteries of the Tripitaka, they were counted as nothing and covered with shame. Therefore foreign students who desired to obtain reputation all used to come to this monastery to solve their difficulties and often the fame of their talents became known afar. And for the same reason those who travelled under the name of pupils of Nalanda could obtain every distinguished honour. If a man of another country wished to enter and take part in the conferences, the guardian of the gate used to put difficult questions to him. The greatest number would be reduced to silence and turned back. It was necessary to have dived deep into ancient and modern books in order to obtain entry there. Consequently the students who journeyed thither to get instruction had to discuss at length in order to show their capacity. Seven or eight out of every ten were always ploughed. In the two or three who were left appeared well instructed they were questioned one by one in the midst of the assembly and every effort was made to blunt the sharpness of their wit and to destroy their reputation ; but those who had high intelligence, vast erudition, strong memory and powerful capacity would add their glory to that of their predecessors and follow their example." This passage is interesting as showing the manner and difficulty of the matriculation examination of those days. Less than thirty per cent. were able to obtain admission within the portals of learning. In the modern Universities of India less than thirty per cent. of the candidates fail to do so. It is also interesting in that it shows that the instruction, like that in mediæval European Universities, was carried on largely by means of public disputations.

Another pilgrim, I-tsing, entered as a student at Nalanda in the latter half of the same century. He had some unpleasant experiences while making his way up from the Hooghly. He was attacked by a disease which sounds rather like malaria. He was also attacked by a band of brigands and, hearing that pale-coloured foreigners were sacrificed to heaven, he disguised himself by entering a muddy hole and covering his body with mud and leaves. He tells how the student began with the commentary of Gayaditya and then occupied the remainder of his two or three years' course with compositions in prose and verse and the study of logic and metaphysic. The following passage indicates the value attaching to the Degrees (if one may use the term) and has a distinctly modern ring about it. " At Nalanda and Valabhi," writes I-tsing, " eminent and accomplished men assemble in crowds, discuss possible and impossible doctrines and, after having been assured of the excellence of their opinions by wise men, become far-famed for their wisdom. They proceed to the King's court to lay down before it the sharp weapon of their abilities; there they present their schemes and show their talent, seeking to be appointed in the practical government. When they are present in the House of Debate they raise their seat and seek to prove their wonderful cleverness. When they are refuting heretic doctrines all their opponents become tongue-tied and acknowledge themselves undone. Then the sound of their name makes the five mountains of India vibrate and their renown flows, as it were, over the four borders. They receive grants of land and are advanced to a high rank; their famous names are, as a reward, written in white on their lofty gates. After this they can follow whatever occupation they like."

The Muslim conquest dealt a blow at Nalanda and other institutions. We hear that, in the reign of Kutb-uddin, Nalanda, still a flourishing monastic University was attacked and not a single scholar was left alive. Nadiya too was destroyed. But the Muhammadans themselves were by no means neglectful of learning. Already, at a date earlier than the Norman Conquest, Mahmud of Ghazni had established a University in Afghanistan and had shown himself a generous patron of learning. It is told of him that he ordered the mouth of the Professor of Philosophy to be thrice filled with jewels as a reward for a smart saying. The invaders brought their culture into India. We hear of a College at Delhi in the reign of the ill-fated Sultana Raziya. The ravages of Chingiz Khan drove a host of learned men from neighbouring countries to the Delhi court; and the poet Amir Khusru says that the city could compete with Bokhara, then the great University city of Central Asia. Gradually schools and colleges rose throughout the land. Jaunpur became a notable centre of the University type. The Mughal Emperors carried on the work begun by the earlier dynasties.

It may be urged that these ancient institutions had little in common with a University as now understood. But they contained the essentials of teaching Universities and in certain respects resembled the mediæval Universities of Europe. They owed their greatness partly to the existence of religious orders and monasteries, partly to regal and private munificence. Notwithstanding their decay under the stress of confusion and war, the torch of learning was handed on under a widely disseminated system of *tols*, whose pandits conferred titles of honour, of *madrassas* and of similar places. Dr. F. W. Thomas, to whom I am indebted for much assistance on these matters, has described the process. "From the simple poets of the Vedic age," he writes, "to the Bengali philosopher of the present day there has been an uninterrupted succession of teachers and scholars. The immense literature which this period has produced is thoroughly penetrated with the scholastic spirit; and the same has left a deep impression on the social conditions of the people among whom that literature was produced." The tradition has survived. The earliest institutions of

British times were moulded on that model. The Universities of to-day have recognised that tradition and contain schools and departments of Oriental learning. The methods of research have changed. But the *tol* has not changed; and modern research depends largely on the *tol* for the supply of its material.

The early European settlers were fully engaged in trade and in war and had little leisure to devote to educational problems. In Portuguese territory, nevertheless, the religious orders had organised a fairly complete system. Tavernier found a splendid Jesuit College in Goa, the partial reconstruction of which, after a fire in 1663, involved an expenditure of about £30,000. With the consolidation of British ascendancy things began to take shape. Governors-General, Governors, the servants of the Company, missionaries and the Indians themselves, all contributed to the building up of institutions of various kinds. Warren Hastings founded the Calcutta Madrassa in 1781. The Sanskrit College at Benares was established in 1792. In 1813 the Court of Directors sanctioned the expenditure of a lakh a year for the revival and promotion of literature and for the introduction and promotion of a knowledge of the sciences. In 1816 the Hindu College was founded at Calcutta by Indians for instruction in English literature and science. Bell, Schwarz and the Society for the Promotion of Christian Knowledge pursued their activities in Madras. The missionaries made great efforts in Bombay, seconded by Mountstuart Elphinstone. It would be beyond the scope of this paper to enter into a description of the beginnings of learning under the British *raj*. But it is necessary to allude to one matter which determined the trend of education in India and was in part responsible for the University system as adopted. This was the controversy between the Orientalists and the Occidentalists. The contest, commenced about the last decade of the eighteenth century, was waged with ever increasing acerbity. The servants of the Company, nervous of the effects of missionising agencies, frequently combined with the more conservative among the Indians to restrict education to the type they had found in existence. The missionaries and the more progressive Indians, especially in Bengal, advocated the introduction of Western learning. The servants of the Crown took up first a mediating attitude, but gradually ranged themselves on the side of the Occidentalists. The Court of Directors, influenced by the mission bodies, advised a cautious advance and went so far as to allow the transmission freight-free of " an extensive philosophical apparatus," consisting of " a complete set of mechanical powers, a complete whirling table," and other strange devices, for the initiation of science in the Hindu College. In 1823 Raja Ram Mohan Roy wrote to Lord Amherst in protest against the founding of the Calcutta Sanskrit College. " If it had been intended to keep the British nation in ignorance of real knowledge, the Baconian philosophy would not have been allowed to displace the system of the schoolmen, which was the best calculated to perpetuate ignorance. In the same manner the Sanskrit system of education would be the best calculated to keep this country in darkness, if such had been the policy of the British legislature." Still more emphatic was Macaulay's Minute of 1835, in which he scoffed at Oriental literature, " its history abounding with kings thirty feet high and geography made of seas of treacle and seas of butter." This was immediately followed by Lord Bentinck's Resolution, which stated that the great object of the British Government ought to be the promotion of European literature and science and that all the funds appropriated for the purposes of education would be best employed on English education alone. But the pendulum had swung too far. The Orientalists were scotched but not killed by Macaulay's antitheses ; and, in 1839, Lord Auckland, while reiterating the prior claims of Western learning, guaranteed the maintenance of existing oriental institutions. We may be thankful that the general policy, inevitably and, on the whole, beneficially adopted, has not excluded Eastern lore and that the study of Oriental literature finds an honourable place in the modern Universities.

And the need for such Universities was beginning to be felt. Indeed, even before 1835 the second period in the history of Indian Universities had commenced—the period of tentative beginnings on a modern type. For there actually existed at that time an institution possessed of the Degree-giving power. Alarmed by the hostility which the Company's servants showed towards missionary zeal, Cary, Marshman and Ward had selected the Danish settlement of Serampore for the headquarters of their labours. In 1827 they obtained from the King of Denmark a Royal Charter empowering the College to confer Degrees of rank and honour ; and the continuance of this power was guaranteed to the College by the Treaty of Purchase in 1845, when Serampore was transferred to the British. As a matter of fact, the privilege was never exercised till 1915, when several Degrees of Bachelor of Divinity were conferred. For ordinary studies Serampore is affiliated to the Calcutta University and will probably confine itself to the conferment of theological Degrees.

Nor was Serampore the only potential University. In 1839 Lord Elphinstone recorded a Minute advocating a University for Madras, open only to those who possessed some knowledge of English. The institution came into existence, first as a high school; a University Board was established in 1841 ; and the school expanded into Presidency College in 1853. Its creation was due to Government order, not to Charter or legislation.

So the first two bodies established in India with modern University aims were definitely teaching institutions. Had their example or that of the old indigenous Universities been followed, the course of University history in India might have been radically changed. But other factors were coming into play. A mass of unconnected institutions, controlled, some by Government, some by Missions, some by Indian committees, had spruug into existence. There were Committees of Education in the Presidencies. But their powers were ill-defined. It was necessary to organise and correlate the competing institutions. The schemes of testing candidates for entry into the public service had presented difficulties. And, in 1836, there had arisen in London a University shaped on a model which seemed appropriate to these needs. Nine years later the General Council of Public Instruction in Bengal submitted a scheme for a central University at Calcutta, based upon that model. Its object was to be the bestowal of marks of distinction upon deserving pupils, so that they might be recognised as fit to enter the learned professions and to occupy the higher offices of Government then open to Indians. The scheme was warmly recommended by Lord Hardinge. But the Court of Directors curtly negatived it.

Another nine years elapsed, and then came the great Despatch of 1854—the Charter of Indian education. It ranged over the whole field and, as regards Universities, declared that the rapid spread of education of a liberal character, the high attainments shown by candidates for Government scholarships and by students of private institutions, the success of the Medical Colleges and other causes had led the Court of Directors to change their mind. Truly a remarkable change in so short a space of time, and no doubt largely attributable to missionary influence, which has played so large a part in the spread of higher education in India. The upshot was that Universities were to be established at Calcutta and Bombay and would be sanctioned at Madras or in any other part of India where a sufficient number of institutions existed. The form and functions were to be those of the London University. But it is noteworthy that additional characteristics were to be, first, the creation of professorships, connected with the University, in subjects for which full facilities did not then exist elsewhere in India, such as law, civil engineering and, strange as it may sound, the vernaculars and learned languages of the country; and, second, periodic visitation of affiliated institutions by Government inspectors.

Lord Dalhousie, while dutifully accepting the scheme in principle, indited a long Minute, criticising details and especially the proposal for University Professors. He thought that sufficient Chairs either existed or would be created in the constituent Colleges. In 1857 Bills were introduced and passed for Universities at Calcutta, Bombay and Madras. In 1882 and 1887 the Universities of the Punjab and of Allahabad were established. All these were of the affiliating and examining type. Only to the last were teaching functions accorded; and those functions were never exercised during this, the third, period of University history.

Now the London model of 1836 had been adopted in London not so much by reason of any inherent excellence as through the well-known difficulties which had assailed the original scheme of a teaching University for London put forward in 1825 by the poet Campbell, Sir Isaac Goldsmid and Lord Brougham. In India the model was deliberately adopted as suitable; and there were created five Universities of the type which depends wholly, so far as teaching is concerned, upon independent institutions. The progress of events in India was just out of step with that in England. One year after the foundation of the first three Indian Universities, the difficulties of the affiliating system of London led to the grant of a new Charter; and, from 1888 onwards, three Royal Commissions have investigated the problem of London University.

Nevertheless, the five affiliating Universities of India, though founded on a model which has since been strongly criticised and often condemned, proved eminently suitable to the conditions prevalent at the time. A number of Colleges had grown up haphazard under different authorities. It was necessary to create a body which should see fair play between them and command public confidence. The country was large and communications were defective. Parents wished to have Colleges at their doors and did not desire that their sons should face the risks which the unfortunate I-tsing encountered—much as the chance of such risks was reduced. It was desirable to recognise Colleges at outlying stations. The scheme adopted was easy and, above all, cheap. It produced some excellent scholars. Perhaps, if the beginning had been made with centralised teaching Universities, the results might in the end have been more satisfactory. But, so long as undue strain was not put upon the system, its inherent defects did not manifest themselves. The strain came when the institutions multiplied exceedingly.

Lord Curzon perceived the danger and sought to meet it. The difficulty was the same as that which was recognised in London in 1858. The standards and conditions of training differed at the different institutions. The Universities had no control over methods of instruction and no power of inspection. The examination had become an end in itself, hampering the teacher, mechanical in its operation and necessarily adapted to the weaker vessels. Lord Curzon appointed a Commission. Witnesses suggested an obvious remedy—the foundation of more Universities. The claims of Bangalore, Trichinopoly and Trivandrum, of Nagpur, of Rangoon and of Aligarh were urged before the Commission. But its members, sensible of the disadvantages which such a multiplication might produce, took a more conservative line and recommended that consideration of so momentous a question should be postponed until the changes they proposed had been tested by experience. The most important among those changes were as follows. While it was deemed expedient that the training of undergraduates should be left mainly to the Colleges, the Universities should justify their existence as teaching bodies by making further and better provision for advanced courses of study. Fellowships (which involved membership of the Senates) were no longer to be given by way of compliment. The conditions of affiliation were to be tightened up. Schools were to be recognised for presenting candidates at matriculation only if recognised by the State.

These reforms, save the last, which was not accepted by Government, were embodied in the Universities Act of 1904. This Act ushers in the fourth period of development. It did not radically change the system. The Government of each University remained vested in a Senate which prescribed courses of study for a number of affiliated Colleges, examined their students and conferred

Degrees. In the words of Sir Hugh Orange, the " principle of the federal University which examines those whom it has not taught received by the Act of 1904 a new lease of life." It is difficult to understand the storm of criticism to which this cautious and moderate measure was subjected. A probable explanation is that the five Universities, brief as had been their existence, and though they were essentially imports from abroad, had endeared themselves to the middle classes, who saw in them a convenient mechanism for hall-marking their sons as fit for employment. Any attempt to touch that mechanism was regarded with suspicion. It was urged against the Bill that the teaching power now bestowed was merely a sham and would remain a dead letter, that private liberality would not be attracted, that the Senates would henceforward be dominantly European, that the Universities would become departments of State, that private institutions would perish and that Western education would be restricted and checked through the malignancy of a jealous Government. Every one of these dismal prognostications was falsified. During the fourth period an elaborate systemof post-graduate study grew up in Calcutta; and similar systems, on a lesser scale, were established elsewhere. So elaborate indeed is the Calcutta scheme that we find eight teachers for nine students in anthropology and the same figures in experimental psychology. Among private donations may be mentioned the benefactions, expressly for University teaching, of Sir Taraknath Palit and Sir Rash Bihari Ghosh, aggregating about £180,000. The Senates, though regulated in their composition and reduced in size (the Bombay Senate had grown to 310 Fellows), have remained largely Indian bodies ; and the number of Indian members is increasing. The Universities have not been devitalised but have shown themselves anything but subservient to Government. Private institutions have not suffered. And above all, so far from the growth of higher education having been checked, the numerical expansion has been unparalleled. From 1902 to 1907 the number of students in Arts Colleges had increased by less than 1,000 ; from 1907 to 1912 it increased by over 10,000. In 1917 the Calcutta University, which sixty years before had only ten authorised Colleges, could boast 58 affiliated institutions with 28,000 students ; and the total for all India was 58,000 students as against 25,000 ten years earlier.

Indeed, the Act of 1904 has often, in the light of subsequent events, been criticised as over-cautious and over-conservative. The fact is that the Commission of 1902 and the Government hesitated to take a plunge not devoid of danger, preferred to repair rather than to replace and deemed it prudent to await the result of their experiment and the ripeness of time. Lord Curzon afterwards said of the Act : " We provide the machinery for reform ; but we leave the Universities to carry it out." How did the Universities perform this task ? The question is hardly a fair one. It would be fairer to ask how could they perform it in face of the overwhelming increase just described ? Assisted by State grants, they did assume teaching functions in varying degrees, and they did commence regular inspections of the Colleges. But each year saw an enhancement of the difficulty which is apt to beset the affiliating University—the impossibility of coping with indefinite expansion. Once more Indian legislation was out of step with the advance of thought regarding the prototype of Indian Universities. In 1898 Parliament had given a new constitution to London University, based partially upon the findings of the second Royal Commission, commonly called the Gresham Commission, which, in opposition to some strongly expressed opinions, had recommended the continuance of a single University for the metropolis, armed both with teaching and with examining functions, the University and its Colleges being more closely welded together through the system of University teachers and Faculties. No doubt this solution was largely present to the minds of the Indian Commissioners of 1902. But already voices in London were being raised against the compromise. In 1910 a third Royal Commission was appointed, which made the following weighty pronouncement. " Experience has shown that the Gresham Commission were mistaken in believing it was in any way possible to organise a homogeneous University by connecting a number of financially and educationally independent institutions with a central degree-giving body endowed with the limited power and influence possessed by such a University as they proposed."

If there was dissatisfaction in London, there was cause for actual apprehension in India. How could the same five Universities which had dealt with less than 12,000 students in 1887 now deal with five times that number ? How could a single University equate through a necessarily mechanical examination hosts of candidates drawn from utterly unequal institutions, among which, in the city of Calcutta, one spent £20 and another less than £4 per annum on the education of each of its pupils ? How could standards be maintained in isolated and often ill-equipped Colleges ? The thing had become impossible. In 1910 a Department of Education was created in the Government of India. In 1913 a Resolution was published in this Department laying down an extensive policy in all branches of education. While recognising the good work done under difficult conditions by the affiliating Universities and the necessity for their continuance, it stated that it was essential "to restrict the area over which the affiliating Universities have control by securing in the first instance a separate University for each of the leading provinces in India and secondly to create new local teaching and residential Universities within each of the provinces in harmony with the best modern opinion as to the right road to educational efficiency." With this pronouncement the Government of India took the plunge, and the knell was sounded of the monopoly hitherto exercised by the five affiliating and examining Universities. The door was opened, and local, provincial and communal spirit took advantage of the opening. The fifth stage of development commenced. In 1917 four new Universities came into operation. Then Government, before proceeding further, decided to obtain the best expert advice as to what is the right road. The Sadler Commission was appointed. Since its report, seven other Universities have come into existence, making a total of sixteen.

What were the defects which the new order sought to remedy ? The Sadler Commission enumerated eleven defects in the University system of Bengal, which was the special object of its enquiry. I do not propose to recite them all. Allusion has already been made to the principal difficulties—excessive numbers and Colleges widely scattered and often meagrely staffed. The Commission endorsed the scheme, already worked out by a Committee under the chairmanship of the late Sir Robert Nathan, for a separate teaching University at Dacca. The Calcutta University itself was to be remoulded on a type declared to be unprecedented, so as to produce a synthesis of the central body and its satellites. Colleges situated in the mufassil were to be placed under a separate Board and would in time either sink to the level of preparatory institutions or crystallise into self-contained Universities. But the Commission made other recommendations of prime importance. First, they pointed out that the system of government through a single body, the Senate, aided by its executive committee, the Syndicate, was ill-devised. They proposed a large Court, deliberative and legislative ; an Executive Council with financial, administrative and certain legislative powers ; and an Academic Council, consisting mainly of University and College teachers, which should be the final authority for the great bulk of ordinary academic business. This recognition of the place of teachers constitutes a radical reform. It had been anticipated by the Government in the Bill which they introduced for the Benares Hindu University. Second, the Commissioners urged that the partial control exercised by the University over schools was inappropriate, overloaded the Syndicate with work and brought it into difficult relations with the State educational organisation. They recommended that secondary education should be placed under the care of a Board of Secondary and Intermediate Education, separate both from Government and from the University but containing representatives of both. Third, they perceived that the Colleges were hampered by undertaking work which properly belonged to the school stage and were clogged by a multitude of pupils unfit to embark on a course of University study and only anxious to obtain admission to a career for which no University training should be required. They accordingly advised that the first two years of the University course, the so-called Intermediate stage, should be relegated to the school organisation and that institutions offering it should be controlled by the Board just mentioned.

As a result of the new policy proclaimed by the Government of India in 1913 and the findings of the Sadler Commission, eleven new Universities have come into being, nearly all of which carry out all or most of the recommendations of that Commission. Bihar and Orissa and the Central Provinces are now served by the Universities of Patna and of Nagpur. Unitary Universities have arisen at Benares, Dacca, Aligarh, Lucknow and Delhi. Burma, which was previously included within the jurisdiction of the Calcutta University, has now its own unitary University at Rangoon. The State of Mysore possesses a federal University, comprising two Colleges in Mysore City and one in Bangalore. The State of Hyderabad has the Osmania University, where the medium of instruction is Urdu. A University for women, independent of Government aid and regulation, has been established by Dr. Karve, with headquarters at Poona. Here also instruction is through the vernacular. Its title is conspicuous for its length. It is known as the Srimati Nathibai Damodar Thackersey Indian Women's University. With the five old affiliating Universities, India has thus sixteen Universities ; or, if the Aligarh Muslim National University be included, seventeen. Proposals are now on foot for an Andhra University in Madras Presidency and a University at Agra.

What of the future ? The resolution of 1913 contemplated a University for each major province and local teaching Universities. Each major province now has its University. Moreover, though the Calcutta University, on which the Sadler Commission reported, has undergone no important change save its transfer to the Government of Bengal, alterations on the lines recommended by that Commission are in process of taking place elsewhere. At Allahabad in particular the constitution and the conditions of recognition have been entirely remodelled. The affiliating University has still a long life before it in India. But an immense stride has been taken in the creation of the local and residential, or, as I have called it, the unitary University, by which I mean not necessarily a single teaching institution, but also a University embracing a limited number of Colleges able, by reason of their contiguity to one another, to co-operate and, so to speak, pool their resources. Thanks to the zeal of Sir Harcourt Butler, this policy has found its most vigorous expression in the United Provinces. Fears are expressed that the multiplication of Universities may produce a lowering of standards owing to unhealthy competition ; and it is pointed out that these schemes have been launched during a period of financial stringency. Any such danger, if it exists, is probably more than counterbalanced by the advantages of the new departure. But further, is not this departure rather likely to raise the standard, if not immediately, at least eventually ? The pressure brought to bear in favour of the cheapening of degrees was already powerful. M. Chailley and others had noted the mediocrity of the normal attainment. Lord Curzon had been invited by respectable newspapers to commemorate the name of Queen Victoria by lowering the examination standard all round. The University has been regarded as utilitarian ; and the gate of learning must not bar the road to livelihood. The policy now adopted is calculated to produce (in the words of the Haldane Report) " A community of workers devoted to the pursuit of knowledge for its own sake and tenacious of this ideal." Surely in such an environment the student is more likely than of old to find his eyes turned to the hills of truth—though without necessarily losing sight of the valley of this world. For in the unitary University may be found concentration, atmosphere, collaboration, a corporate spirit and local enthusiasm, where formerly there existed isolation, divided effort and cryings in the wilderness. Again, the reformed Indian University will no longer have to cater for the lad whose abilities and ambitions limit him to some walk of life for which no University training, worth the name, is required. For the Intermediate classes are there excluded, just as in England the Universities have through centuries been transferring such studies to the more important schools and concentrating on higher work and better brains. Further, by the creation of proper academic bodies the teacher has come into his own; and the majority of Indian collegiate teachers, who have taken up the profession seriously, are rightly zealous that their students should attain a good standard. Finally, the residential University bids fair largely to remedy the unwholesome conditions under which so many students have lodged in the past.

The foregoing remarks necessarily omit many aspects of Indian Universities. It has been possible to give only a brief and bird's-eye view of their history—the ancient foundations; their decay under the stress of war and anarchy; the handing on of the torch through humbler institutions; the introduction of Western learning under an ordered Government; the inevitable demand for Universities of the Western type to crown the fabric of the new system; their creation in a form suitable to local conditions but big with potential difficulties; the manifestation of those difficulties as the numbers to be handled increased; the remedies adopted; and finally the recognition of the need for a supplementary system of local teaching Universities. I do not pretend to generalise about the relative merits and defects of large affiliating Universities and small unitary Universities. But the moral is clear as regards India—however convenient may be the former type it is not capable of indefinite expansion and at the same time of maintaining its efficiency. It is by no means dead and in some instances, it may be urged, it is not yet overgrown. But it is in the success of the latter type that the future of University education in India mainly rests. "The reform," said Lord Reading in May last, "is proceeding, hampered, it is true, in many cases by difficulties of finance, but proceeding nevertheless with a wider horizon of intention and a greater variety of aims than at any past period of University history in India."

DISCUSSION.

THE CHAIRMAN (Viscount Chelmsford) congratulated the author on the extremely interesting paper he had presented. If there was one criticism he could make in regard to it it was that the author had been too discreet. A man so well qualified as the author might have let himself go on the present occasion, now that he was free from the trammels of office, and it would have been of great value to hear his freer observations on the problems outlined in the paper.

He thought no one could be altogether happy about the history of education in India under British rule. It might be said to have begun with Macaulay's great Minute, to which the author had alluded, and the decision of Lord Bentinck's Government to adopt English as the medium of instruction. That decision had been fraught with most momentous consequences, not only in the educational, but in the political sphere.

When he himself was in India he had often spoken to Indians who were interested in educational problems, and, anxious as they were for all they could get out of Western education, they expressed the view that the Minute to which he had referred gave far too decided a bias in the Western direction to the whole trend of education in India, and ignored the fact that there could be anything good in Eastern institutions or methods.

Turning to the political aspect, it could not be denied that nearly all the political development which had taken place in India in the last hundred years had been the logical and inevitable result of the policy which was laid down by Lord Macaulay and adopted by the Government of that time, because it at once introduced Indians to Western political ideals and aspirations, whether or not those ideals or aspirations were best suited to the East. One could not hold out in one's educational system certain ideals and aspirations as the best the West could offer without the demand for them being made and inevitably granted, whereas probably it would have been far better for the East to develop its own ideals and aspirations.

One could not be altogether happy, moreover, about the development that had gone on in India of the higher rungs of the ladder, in view of the fact that the lower rungs of secondary and elementary education had been so neglected. The result was seen in the findings of the Sadler Commission, that there was a large number of students going up to the Universities imperfectly equipped for taking advantage of University education, because they ought to have attended secondary schools for at least another year or two. Consequently, the Universities were given up in the earlier stages of undergraduate life to teaching which a University ought not to give, and which certainly ought to have been finished with in the secondary schools. Thus arose the swelled numbers which were another obstacle in the way of the proper administration of the Universities.

It had fallen to his lot to appoint the Sadler Commission. He visited Calcutta University about six months after he was appointed Viceroy, and became convinced that what was required was guidance from a Commission which would have no political side to it at all, but which would be entirely composed of educationalists of the highest stamp. He had been careful to confine the inquiry to Calcutta, because he felt that what could be got from the examination of one great University would give guidance with regard to Universities generally in India. It was impossible, of course, for the Commission to examine the problems of Calcutta University *in vacuo;* they visited and made themselves acquainted with the conditions of other Universities in India, but they had as their text Calcutta University. Any one who took the trouble to read the massive tomes which were the result of the two years' work of Sir Michael Sadler's Commission would feel that it had done its work well and worthily, and that the gentlemen who served on the Commission deserved commendation for what they did.

As the author had stated, Calcutta University had not really attempted to profit by the Report of the Commission, but the work of the Commission had not been altogether in vain, because other Universities had taken its Report very largely as their guide for reform and development, and thus one of the purposes for which the Commission had been appointed had been fulfilled.

It must be confessed that British rule and British administration were responsible for the present state of affairs, but in many matters the hands of the Government had been forced by the public demand to follow a certain course. The author had once told him that he did not doubt that even the Minute of Lord Macaulay was very largely influenced by the state of public opinion amongst educated Bengalis when he wrote it. Ever since then the pressure on the part of the educated classes for higher education as distinct from secondary and elementary education, had been a very potent factor in the policy which had been pursued.

It was all the more disappointing when one remembered the extraordinary zeal which was displayed by many of the students and undergraduates. He had been greatly impressed in going over Calcutta University and its hostels to find that the boys were memorising whole text-books. That, of course, was not the sort of instruction which a boy should get from a University, but it was a standing testimony to the zeal, grit and determination of the boys who did it.

He remembered the late Mr. Bhupendranath Bhose, who was a master of the English language, and who could put many English people to shame by the choiceness of his language and the perfection of his form, as well as the ease, facility and clarity with which he expressed his views, telling him that in his student days he found himself confronted with a question in his Examination paper the answer to which he knew was to be found on a certain page of a text-book which he had memorised. His knowledge of English at that time, however, was so poor that he did not know what portion of the page contained the answer to the question and so he put the whole page down as the answer, and felt very much aggrieved when the examiner did not give him full marks, but pointed out that though it was true that, contained in what he had written was the answer to the question, it was quite obvious from the irrelevant matter he had also put down that he did not apprehend the question asked of him.

Personally, he could not look on a thing like that except with the greatest admiration. If English people had the same thirst for education that the Bengali students displayed it would be a wonderful thing for the country, and it was all the more tragic that, through the mistaken policy in University education which had been pursued, Indian students had not been able to get the best out of their University training.

He regretted the fact that it had been the policy in India to use University Degrees or Examinations as a passport to Government employment. That put the University in an entirely wrong position. So far as the Indian student was concerned, it led him to believe that the purposes of a University were something quite different from what they ought to be.

Sir Claude F. de la Fosse, C.I.E., M.A., D.Litt., said the author had been careful to steer clear of the rocks of controversy in his very comprehensive and lucid, but cautious, account of Indian education. Personally, he (the speaker) was chiefly interested in the work done by the Sadler Commission and its influence upon the older Universities, and the results it produced in the Universities which had been created since that Commission reported. It had fallen to his lot to prepare drafts for four Bills for the reform of old and the constitution of new universities, in accordance with the recommendations of the Calcutta University Commission. As Vice-Chancellor of one of those universities he had gained further experience of the subject.

In the United Provinces, with which he was best acquainted, the politicians were not much enamoured of the old system of affiliating universities, and put up very little opposition to the reform of Allahabad University and the creation of a new University at Lucknow. They saw in the creation of the new Universities a form of university government which was more representative, and they hoped to get a larger influence in the direction of university policy. They endeavoured to get the Bills modified in the Council with a view to giving themselves more representation upon the executive authority of the university and a larger representation upon the court. At the present time a member of Council was a very important person in India. A man who was on the Legislative Council was held in great awe, and the politicians probably hoped they would be treated by the universities with the same respect as they were in their own constituencies. After he had served as Vice-Chancellor for some time, he came to the conclusion that nothing but good had come from the democratisation of the boards of the universities which was thus brought about. At the first meeting of the court several leading politicians thought it advisable to talk in the same general manner on education that they were accustomed to do to their colleagues on the Council, but they came up against the teachers at once. When they proposed that the University should be more sympathetic towards candidates for examination they were asked what they meant, and had to explain that they meant lowering the standards, and then they got themselves into trouble. After a time they became cautious about what they said. By serving on the University boards and learning the views of the university, they came to look upon it as their duty, as members of Council, to examine closely criticisms of the University in the Council, and to help the University wherever they considered it needed help. Their work in the University was an education to them in University matters. and at the same time the University obtained a great deal of valuable assistance from them in times of crisis in the Council.

Turning to the academic side, under the old system a professor was liable to work in isolation. A Professor of Physics, for example, however eminent, might find himself at a distant college where he had no stimulus from his colleagues, and where he found the steady grind of instructing pupils of a low standard of attainment very irksome, so that he gradually got stale. Under the new system there was a head for each department of teaching, with a number of colleagues under him, and there was rivalry between the departments to produce really good work. Under the old system there was no opportunity for an ambitious young teacher to win distinction, but now, if he were anxious to gain the respect of his colleagues, he had to work continuously and had to go in for research.

There was a great deal of enthusiasm for research in the younger Universities at the present time. The work done so far was not of great importance, but the spirit was there. There was a natural tendency to produce results too soon, but before long a teacher who was at the head of a department would be able to persuade his juniors not to publish their work until they had studied the questions with which they were dealing more thoroughly.

There was, under the new system, a stimulus for higher and better teaching which would react on the student community, and, instead of working solely for the purpose of getting a Government appointment, the better students were beginning to work for the sake of the work, from a desire to promote learning. That tendency, in the Allahabad and Lucknow Universities at any rate, was quite marked. For many years the Indian student took little interest in history, but now the work being done in the historical department by students was of great value. There was an immense field for research before them and they were beginning to get to work upon it. That kind of thing was practically impossible under the older system, where the colleges were scattered about, and where the teachers only met once or twice a year to discuss their courses and examinations. There was no doubt that on the academic side the new Universities were an improvement on the old.

With regard to the student community, the bringing together into one place of a large number of young men led to some letting off of hot air in the debating societies, but it did not go beyond that. They were now better looked after; they were organised in hostels and had their tutorial instruction. Even day scholars were attached to hostels so that they might have their tutorial work in the hostel. They were all kept busy, and there was very little time for them to make themselves troublesome in the towns. There was now greater rivalry for pre-eminence. To be the head of a learned association was a great ambition among them, and undoubtedly the games were carried on very much better than they used to be. Under the old system military training was an impossibility; but now that the corps were centred at residential Universities they were receiving military training under British sergeants, and the sergeant instructors had been astonished at the enthusiasm and interest they were displaying.

Principal Mohan Lal Tannan, Sydenham College of Commerce and Economics, desired to refer to two aspects only of university education in India. In the first instance, he wished to deal with the general apathy which Indian universities showed towards higher commercial education. The lecturer referred to the Paradise which was in store for a good many Indian graduates—clerkships at £40 a year. The reason for that was, to a large extent, the fact that Indian universities did not really recognise certain branches of education. It was only in 1912 that the University of Bombay gave a lead in the matter. The Government of Bombay then started the Sydenham College of Commerce and Economics. That lead was followed by other universities and by other Provincial Governments, and to-day a good many of the Indian universities conferred the degree of Bachelor of Commerce. Last year the University of Bombay took a further step in the matter and instituted the higher degree of Master of Commerce. He hoped further encouragement would be given to higher commercial education, because if India wished to develop her industries and commerce it was essential that those who were to be the heads of the various commercial houses and industrial concerns should be properly trained.

The second point to which he wished to refer was the poverty of the average Indian student as far as general knowledge was concerned. For that too he was afraid the Indian universities were responsible to a large extent. There were universities even to-day which did not encourage the study of such subjects as geography. It was only a few years ago that, thanks to the efforts of Sir Harcourt Butler, it was decided to have a Chair of Geography at the University of Allahabad, but, unfortunately, up to the present, that Chair had not been filled. It was essential that Indian students should possess more general knowledge, as did students in the West, so that they might be fitted for different kinds of work, and not only know to cram up books for passing examinations.

Dr. F. W. Thomas, M.A., Ph.D., thought it would be universally admitted that without a spirit of research the spirit of university life could not be said to exist. The research work which was being carried out by Indian universities at the present time was of considerable value. Economics was encouraged in Calcutta, Bombay and Madras; history in Allahabad and Calcutta; and in the last-named many other branches of study were encouraged and valuable works constantly produced.

The pre-Muhammadan history of University education in India was very fragmentary, and the subsequent history of Hindu education, until the time when the British took it up, was a process of almost continuous decay. It must be recognised, however, that when the British started operations in India, they were able to work to a considerable extent on a foundation of both primary and higher educational institutions which existed among the Hindus. It was unfortunate that political and other controversies intervened at an early period, and the effects of them remained at the present time. When Macaulay went out as Educational Member to India in 1835, he practically carried with him his Minute in his pocket. It was an old question, and the factors which decided it were not entirely educational, but had much to do with the position of the missionaries and their attitude towards native learning. The pandits of the Hindu college were well aware of what they had to expect from Macaulay's accession to power.

He would like to ask the author whether he thought that the question of orientalism and oriental studies in Indian education might be taken now as settled. He was told that in Benares alone there were at least 100 native *tols*—private schools—where the education was given by pandits in the old Hindu fashion in their own houses. It frequently happened, he believed, that those who took their degrees in the University of Benares received the training for their degrees in the tols. He had some acquaintance with pandits and others interested in oriental learning, and the question was one which he found very interesting. He would, therefore, be glad to have some idea of whether the question of the relation of native Hindu learning to the universities might be regarded as now settled.

In this country a large proportion of the students in the Universities were preparing for professions such as law or medicine, and there was no doubt as to the relation between their studies and the professions they were destined to follow. That was more or less the case in India also, because the modern pursuit of medicine and law in India had taken the direction dictated by European knowledge. That did not apply to the religious sphere at all, and it applied only partially to the sphere of medicine, because there had been a marked reaction in India during the last generation towards the Hindu and Muhammadan systems of medicine. To a lesser degree the same was the case with regard to certain portions of legal education. Taking the matter of science alone, there still remained an important unsolved question as to the relation between university studies in India and the life of the people.

He could not help thinking that the linguistic question again was one which of necessity preesnted itself at the beginning of university and higher education in India, and one which had still to be definitely settled.

LORD CHELMSFORD, having to leave the meeting, the Chair was taken by COLONEL SIR CHARLES E. YATE, Bt., C.S.I., C.M.G.

MR. R. à-ABABRELTON said unfortunately there was considerable disloyalty amongst students who came to this country from India. Could not something be done to obviate that?

MR. THOMAS W. HODGKINSON said that, as one having some knowledge of India, he recognised there was a huge field open to Indian students if they could get some qualification which would hall-mark them to show their efficiency for business, commercial and industrial positions. He did not think one could employ the advantages of the universities to the full extent by allowing so many of their students to become clerks at Rs. 40 a month; there were many callings which were open to Indians of good character and education in commerce, and in which they could rise to positions of considerable importance if they could first get satisfactory commercial qualifications.

The Chairman (Colonel Sir Charles Yate) said the paper under discussion had given him a more hopeful idea of Indian universities than he had entertained for a considerable time. He felt doubtful, though, whether he could acquiesce in the author's opening remarks, where he said that universities in India were a cause of self-congratulation to the Government. He had never thought they were that, because it seemed to him they turned out a lot of ill-disciplined and half-educated boys who were not properly taught, and who had had no proper system of education. The author went on to say that the universities served as a convenient platform for budding politicians. He did not know that it was the aim of the Government of India to create politicians. The author had also said that university education might mean anything from a passport to paradise to a clerkship of £40 a year, but that gave an imperfect idea of what the value of a university degree was in India. He had recently seen an extract from an Indian paper reporting a speech in the Legislative Asembly in which Mr. Bepin Chandra Pal had stated that the current price of a Hindu bridegroom, if he were a B.A., was Rs. 5,000, while that of the M.A. was higher still. To show that that was not exaggerated, details were given of a price which a Hindu father put on his son who had returned from England and entered the Service on Rs. 375 a month. The total amount was given as Rs. 8,400. From that he gathered that a certain monetary value was put by Bengali students on a university degree.

The question to be considered was what useful purpose was served by an Indian university degree. The standard exacted for the Calcutta University Matriculation was so low as to be altogether worthless. It was very difficult to get an idea of the comparative value of the degrees given by the different universities in India, and he gathered that the Revenue Member had himself stated that he could not appraise the value of the degrees conferred by the various universities in India when he had to select candidates for appointments to the various Departments. The standards were both variable and altogether too low. He had asked many questions in the House of Commons with the object of having the standard of examinations raised, if possible, to that prevailing in the universities in this country. He wanted Indian universities to confer degrees which would be recognised as being equal to those given by English universities, so that Indian university degrees might be recognised in the United Kingdom. He hoped the author would be able to say what steps were being taken to increase the value of the examinations, and to stop the enormous rush of half-educated boys into the universities.

What should be given in India was a useful, practical, technical education. Memorising should be stopped. He hoped the Government of India would take the question up and endeavour to see that a really practical education was given, and not permit the present system to continue, which only turned out annually thousands of half-educated young men unfitted for agricultural, industrial or commercial pursuits.

Sir Henry Sharp, in reply, said that if any progress had been made in university education in India it was largely due to the sympathetic attitude adopted by a succession of distinguished Viceroys, who had taken the greatest interest in the subject; and of them none was more sympathetic nor more interested than Lord Chelmsford.

It had been said that the paper was over-cautious. He had thought it his duty to narrate and not to criticise; but there were a good many things he could have said which might be rather disturbing to some of those present.

Lord Chelmsford put his finger on a very important point when he spoke of the wholesale adoption of Western ideals in India. That was inevitable. The Government of India, even in 1835, had lost control of the movement; but the fact of the matter was that Western influences had gone too far in education. There had been a rush for the learned professions, which caused an unnatural spread of higher education. The passion for employment in those professions or in Government service created an enormous demand for education of the so-called higher type, and when that was supplied, it in turn created a demand which it was impossible to meet for posts in the professions and services. That led to M.A.'s getting employment at £40 a year. Another result was that technical education had been thrust into the background, because the universities had grown up with a literary bias. Technological institutes had not flourished as they should have done. It was the idea of the new Unitary Universities that a cure should be provided for that sort of thing. Owing to the very important recommendations made by the Sadler Commission, the lower strata had been cut off from university education and put where they ought to go—into the school organisation.

He had heard from many sources that the introduction of politicians into the University Courts had had a good effect. Personally, he had always been afraid of them, but experience seemed to show that they had done well; he gathered that the universities had taught the politicians something. He was also glad to hear that research was showing signs of flourishing in the universities. That was only natural It could hardly do so in the older universities, where the colleges were so scattered.

Dr. Thomas had asked a very important question—whether the matter of oriental studies in India was settled. A conference of orientalists was held in Simla in 1911, and, when one considered that India was not a fast-moving country, he thought it would be prudent to wait for a decade or two until the results of that conference became apparent! He admitted that there was a lack of correlation between the universities and the life of India; that was due to the fact that there was so much more higher education than lower education in India. There was an amount of higher and university education comparable to what was found in Europe, whereas, when one went further down, there was only the minutest fraction of the amount of lower education.

Personally he was very much interested in the question of medicine, because he had a good deal to do with the medical services. An interesting problem which awaited solution was the utilisation of the undoubted knowledge of Eastern doctors by Western medicine. That was to some extent beginning, but there was considerable room for development.

With regard to what Principal Tannan had said, he thought there was very great need for technical education in India, and he had the highest respect for the work done by the Sydenham College of Commerce in Bombay, but he thought that the work which that and similar institutions were doing should be done apart from the universities altogether. He would prefer to see institutions of that kind independent of the Universities and growing up along their own lines. In dealing with the question in India he had been almost overwhelmed by the strength of public opinion in favour of putting such institutions under the universities, because of the possibility of conferring university degrees. The diplomas of independent institutions did not carry anything like the same force in India as university degrees, which showed the hold the universities had over the people. He would rather see a greater variety of institutions.

As to the disloyalty of Indian students, which had been mentioned, he thought they learned a great deal of it in this country.

With regard to Sir Charles Yate's remarks, he thought that a B.A. who was worth Rs. 5,000 must be a Brahmin or a Kulin Kayasth in addition. His academic qualifications alone would not make his value so enormous. He had been asked what useful purpose the university served in India. He had not definitely said that it served any useful purpose at all, but at the same time it was necessary to have universities; one could not have an educational system such as existed in India without a coping stone at the top. He admitted the grave defects which had at times disfigured university education in India in the past, and he entirely agreed that the standard of degrees was very low. He hoped that the new universities might help to raise that standard. At times he had made himself unpopular in India by trying to get the standard raised, but at the moment there was no examination standard laid down comparable with that of any institution in England, except for the fact that a certain number of schools examined for the Cambridge Local Examinations. He thought some English commercial diplomas were also examined for in India. The low standard prevailing was greatly to be regretted, but it did not prevent Indian students from rising to a very high standard when they were well-taught and had natural capacity. He thought the new Unitary Universities would provide a cure, but the remedy must be very slow, because the evil had gone so deep.

On the motion of Sir Robert W. Carlisle a vote of thanks to the author was carried unanimously.

Sir Edward A. Gait, K.C.S.I., C.I.E., writes :—

I am very sorry that I was unable to wait for the discussion of Sir Henry Sharp's interesting paper, as there were several points I should have liked to mention. In particular I should have liked to refer to the prospects of University education in India. Sir Henry thinks that the change resulting from the multiplication of Universities, especially those of the " Unitary " type, justifies an optimistic view. There is, however, another new factor, which seems to me to point in the opposite direction. Under the reformed scheme of Indian Government, education, in all its branches, is one of the departments which has been handed over to popular control; and, though there are, no doubt, many who think differently, the vast majority of Indians hold strongly to the view that, whatever else it may be, education must be cheap, and that a University degree, as the necessary passport to remunerative employment, must not be very difficult to obtain. When such views prevail it is idle to expect any improvement in university education in India.

An instance of the way in which this feeling finds practical expression has just been afforded in my old province. The scheme for the Patna University, which had been prepared by the local Government and accepted by the Government of India, before the introduction of Dyarchy, provided for the replacement of the existing colleges in Patna City by new buildings on a spacious site outside the city, where up-to-date lecture rooms, laboratories, hostels, etc., would be erected, and proper arrangements would be made for the varied intellectual, social and sporting amenities which a modern university should provide. This scheme has now been abandoned, and it has been decided instead to extend the present obsolete buildings on their crowded site in the heart of the city, where the true university atmosphere can never be developed. This decision has been reached, not in a spirit of opposition, but after a *bonâ fide* consideration of the facts, on the ground that the original plan would place an honours course beyond the means of the poorer students.

NOTES ON BOOKS.

ISLANDS: WEST INDIAN-AEGEAN. By Sir Arthur E. Shipley, G.B.E., F.R.S. London: Martin Hopkinson and Co., Ltd. 6s. net.

This book is the result of two trips made by Sir Arthur Shipley—the first to the West Indies, whither he went, as Chairman of the Governing Body, to take part in the laying of the foundation stone of the Imperial College of Tropical Agriculture in Trinidad; the second to the Isles of Greece. Many of the chapters appeared in *The Times*, but those who read them there will be glad to see them again in this handy form.

Many people have visited the West Indies and written about them, but Sir Arthur Shipley comes with a fresh eye and some of the solutions which he suggests of difficult problems are, to say the least, original. Thus, his proposal to secure sufficient coolie labour for British Guiana is delicious. "The East Indian is clamouring to get into Kenya, where he is not wanted, and he declines to enter British Guiana, where he is welcome, and where he frequently raises himself to a position of independence and often of affluence. The opinion of those qualified to judge is that the only chance of attracting him back to British Guiana is entirely to forbid his landing there."

A good deal of the book is naturally devoted to the Imperial College of Tropical Agriculture. The potential wealth of the tropics is incalculable, but if it is to be developed on sound lines it must be able to rely on the aid of up-to-date scientific knowledge. Many problems are calling urgently for investigation, and research into these will form not the least valuable part of the work of the College. It will also form not the least expensive part of it, and it is to be hoped that planters and others who will reap the benefit of these investigations will be ready to contribute liberally to the support of the new foundation.

The second part of the book records a pleasant yachting trip of five weeks spent among the Isles of Greece. This portion is illustrated by some interesting photographs of the Street of the Knights, Rhodes, and also of Santorini. Comparatively few people have visited this, the southernmost isle of the Cyclades, but Sir Arthur considers it the most fascinating of all the Aegean Isles.

THE HISTORY AND ROMANCE OF CAVENDISH SQUARE AND ITS VICINITY.—By Percy Rudolph Broemel, F.R.S.A. Second edition. London: T. B. Mills. 1s. net.

Cavendish Square and its neighbourhood have been associated with many famous names. The first house to be completed was Harcourt House, designed by Inigo Jones. The foundation stone was laid in 1722, and later on the house passed into the possession of the Duke of Portland.. It was the original of "Gaunt House" in "Vanity Fair." Unfortunately, it was demolished in 1904 to make room for residential flats.

Number 18 has been occupied for the last eight years by the Consulate-General for the United States of America, with which office the author of this pamphlet is connected. The present house was built in 1750, but probably there was a much earlier building on the site, as there are still in existence underground passages and a dungeon, and, it is alleged, a ghost who wears the uniform of an officer of Charles II.

Mr. Broemel has been at great pains to identify the various houses in Cavendish Square and its vicinity associated with the names of famous men and women, and his booklet gives much information about an interesting neighbourhood.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock :—

APRIL 22.—CEDRIC CHIVERS, J.P., Mayor of Bath, " Bookbinding." EMERY WALKER, F.S.A., will preside.

APRIL 29.—ANDREW BALFOUR, C.B., C.M.G., M.D. (Edin.) B.Sc., D.P.H., F.R.C.P.E., " The Trend of Modern Hygiene." SIR GEORGE NEWMAN, K.C.B., M.D., D.C.L., F.R.C.P., Chief Medical Officer, Ministry of Health, will preside.

MAY 6.—AIR VICE-MARSHAL SIR WILLIAM SEFTON BRANCKER, K.C.B., A.F.C., Director of Civil Aviation, Air Ministry, " Commercial Aviation." HIS GRACE THE DUKE OF SUTHERLAND, President of the Air League of the British Empire, will preside.

MAY 13.—(Joint Meeting of the Royal Society of Arts, the Royal Aeronautical Society, and the Anglo-Batavian Society.) THOMASSEN À THUESSINK VAN DER HOOP, " The Flight to the Netherlands East Indies." (The paper will be read in English). AIR VICE-MARSHAL SIR WILLIAM SEFTON BRANCKER, K.C.B., A.F.C., will preside.

MAY 20.—PROFESSOR JOHN AMBROSE FLEMING, M.A., D.Sc., F.R.S., " William Sturgeon and the Centenary of the Electro-magnet." ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council of the Society, will preside.

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

MAY 8.—SIR GILBERT T. WALKER, C.S.I., M.A., F.R.A.S., Sc.D., Ph.D., F.R.S., " Indian Meteorology."

MAY 22.—SIR ALFRED CHATTERTON, C.I.E., B.Sc., Assoc.M.Inst.C.E., " The Industrial Progress of the Mysore State."

JUNE 12.—BRIGADIER-GENERAL SIR PERCY M. SYKES, K.C.I.E., C.B., C.M.G., " The Heart of Asia and the Roof of the World."

DOMINIONS AND COLONIES SECTION.

Thursday afternoon, at 4.30 o'clock :—

JUNE 18.—HON. W. G. A. ORMSBY-GORE, M.P., Under Secretary of State for the Colonies, " East Africa."

HOWARD LECTURES.

Monday evenings, at 8 o'clock :—

PROFESSOR JOHN SAMUEL STRAFFORD BRAME, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, " Motor Fuels." Three Lectures. April 20, 27, May 4.

SYLLABUS.

LECTURE I.—APRIL 20TH.

Problem of Motor Fuel Supply. Sources and production from Petroleum—(" straight " spirit, casing head spirit, and " cracked spirit "). Motor benzole, Power Alcohol. Denaturants. Storage, handling and fire risks.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

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MONDAY, APRIL 20..Cold Storage and Ice Association, at the Royal Society of Arts, John Street, Adelphi, W.C. 5 p.m.

Brewing, Institute of, at the Engineers' Club, Coventry Street, W. 7.30 p.m. Messrs. H. W. Harman and J. H. Oliver, "Yeast Pressings."

Transport, Institute of, (Midland Section), at the Chamber of Commerce, Birmingham. 6 p.m. Mr. F. T. Walker, "Shipping from the Provinces."

British Architects, Royal Institute of, 9, Conduit Street, W. 8 p.m. Mr. P. J. Waldram, "Natural and Artificial Lighting."

Geographical Society, Lowther Lodge, Kensington Gore, S.W. 5 p.m. Dr. V. Meinesz, "The Determination of Gravity at Sea in a Submarine."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 7 p.m. (Informal Meeting). Discussion on "Latter-Day Wireless."

Victoria Institute, Central Buildings, Westminster, S.W. 4.30 p.m. Rev. President M. G. Kyle, "Genesis Record and the Antiquity of Man."

Automobile Engineers, Institution of, (Local Centre), at the Chamber of Commerce, New Street, Birmingham. 7 p.m. Mr. G. W. Watson, "Brakes for Motor Vehicles."

TUESDAY, APRIL 21..Statistical Society, at the Royal Society of Arts, John Street, Adelphi, W.C. 5.15 p.m.

British Architects, Royal Institute of, 9, Conduit Street, W. 5 p.m. Mr. R. L. Rathbone, "Metal Work."

Transport, Institute of, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C. 5.30 p.m.

Anthropological Institute, 52, Upper Bedford Place, W.C. 2.30 p.m. (Joint Meeting with the Prehistoric Society of East Anglia.) 1. Mr. H. Balfour, "Tasmanian Stone Implements." 2. Miss N. F. Layard, "Recent Excavations on the Neolithic Site at St. Gertrude, Holland." 8.15 p.m. Ordinary Meeting. Paper on Recent Excavations on Palaeolithic Sites at Creswell Crags, Derbyshire."

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Mr. D. Paterson, "The Johore Causeway."

Photographic Society, 35, Russell Square, W.C. 7 p.m.

Physiology, London College of, 8, Taviton Street, W.C. 8.15 p.m. Dr. S. Zarchi, "Mind and Disease."

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. J. Barcroft, "The Effects of Climate on the Circulation." (Lecture I.)

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C. 4 p.m. Lt.-Col. R. E. Snowden, "Tasmania: the Development of New Country."

WEDNESDAY, APRIL 22..Master Glass Painters, British Society of, at the Art Workers' Guild, 6, Queen Square, W.C. 6 p.m. Mr. J. A. Knowles, "The Preparation of Mediæval Designs for Stained Glass."

Meteorological Society, 49, Cromwell Road, S.W. 3 p.m. Prof. E. van Everdingen, "Clouds and Forecasting Weather."

India Society, 21, Cromwell Road S.W. 9 p.m. Lecture by M. Silvain Lévi.

Mechanical Engineers, Institution of, (Yorkshire Section) Sheffield. 7.30 p.m. Prof. G. F. Charnock, "Some Fallacies concerning Invention"

Automobile Engineers, Institution of, (Local Centre). 244, Deansgate, Manchester. 6.30 p.m. Mr. G. W, Watson, "Brakes for Motor Vehicles."

Civil Engineers, Institution of, Great George Street, S W. 6 p.m. (Students' Meeting).

Geological Society, Burlington House, Piccadilly, W. 5.30 p.m. Mr. W. L. F. Nuttall, "The Stratigraphy of the Laki Series (Lower Eocene) of parts of Sind and Baluchistan (India); with a Description of the Larger Foraminifera contained in those Beds."

THURSDAY, APRIL 23..Petroleum Technologists, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 5.30 p.m. Prof. Koggernan, "The Present Status of the Oil Shale Industry in Esthonia."

Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p.m.

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. Col. K. G. Maxwell and Mr. A. Monkhouse, "Recent Improvements in the Insulation of Electrical Machinery."

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

Automobile Engineers, Institution of (Graduates' Section), York Buildings, Adelphi, W.C. 7.30 p.m. Messrs. Buck and Hickman, "Modern Machine Tool Methods."

Royal Institution, Albemarle Street, W. 5.15 p.m. Mr. F. K. Ward, "A Year's Exploration in Tibet." (Lecture I.)

Mechanical Engineers, Institution of, (Western Centre), at the Merchant Venturers' Technical College, Unity Street, Bristol. 7 p.m. Mr. E. S. Coward, "Patents and Inventions."

Linnean Society, Burlington House, Piccadilly, W. 5 p.m. 1. Mr. J. Parkin, "A Unique Feature in the Petal of *Ranunculus*, with remarks on the Phylogeny and Taxonomy of the Genus. 2. Mr. K. Rees, "Investigations into the Distribution and Ecology of Phaeophyceæ in Wales."

China Society, at the School of Oriental Studies, Finsbury Circus, E.C. 5 p.m. General S.T. Hsu, "Chinese Music."

FRIDAY, APRIL 24..Engineering Inspection, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 8 p.m.

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 6 p.m. Reports to the Hardness Tests Research Committee. 1. Mr. G. A. Hankins "The Effects of Adhesion between the Indenting Tool and the Material in Ball and Cone Indentation Hardness Tests," 2. Mr. G. A. Shires, "Some Practical Aspects of the Scratch Test for Hardness."

Electrical Engineers, Institution of, (Scottish Centre), at the Technical Institute, Dundee. 7 p.m. Discussion on "Justifiable Small Power Plants."

Metals, Institute of, (Local Section), at the Mappin Hall, The University, Sheffield. 7.30 p.m. Mr. B. Carr, "Chromium Plating."

Aeronautical Engineers, Institution of, at the Engineers' Club, Coventry Street, W. 6.30 p.m. Commander C. D. Burney, "The Position of the Air Ship in Aerial Transport."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. J. E. Saunders, "Close-up Portraits from the Zoo."

Physical Society, at the Imperial College of Science, South Kensington, S.W. 5 p.m. Prof. W. Wien, "Recent Researches on Positive Rays." (Guthrie Lecture.)

Philologie, Sciences et Beaux-Arts, Sociétie Internationale de, 8, Taviton Street, W.C. 8.15 p.m. Mr. H. R. Hough, "The Story of the Bagpipes."

Royal Institution, Albemarle Street, W. 9 p.m. Prof. W. A. Craigie, "The Icelandic Sagas."

SATURDAY, APRIL 25..Royal Institution, Albemarle Street, W. 3 p.m. Mr. W. P. Pycraft, "Use and Disuse—the Effect on Structure of Animals." (Lecture I.)

JOURNAL OF THE ROYAL SOCIETY OF ARTS

No. 3779. VOL. LXXIII.

FRIDAY, APRIL 24, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, APRIL 27th, at 8 p.m. (Howard Lecture.) PROFESSOR JOHN SAMUEL STRAFFORD BRAME, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, " Motor Fuels." (Lecture II.)

WEDNESDAY, APRIL 29th, at 8 p.m. (Ordinary Meeting.) ANDREW BALFOUR, C.B., C.M.G., M.D. (Edin.), B.Sc., D.P.H., F.R.C.P.E., " The Trend of Modern Hygiene." SIR GEORGE NEWMAN, K.C.B., M.D., D.C.L., F.R.C.P., Chief Medical Officer, Ministry of Health, will preside.

DOMINIONS AND COLONIES AND INDIAN SECTIONS (JOINT MEETING.)

THURSDAY, 16th APRIL, 1925. SIR CHARLES CAMPBELL MCLEOD, Bt., in the Chair.

A paper on "The British Empire Exhibition" was read by Lord Stevenson, G.C.M.G.

The paper and discussion will be published in a subsequent number of the *Journal.*

HOWARD LECTURE.

On MONDAY, APRIL 20th, PROFESSOR JOHN S. S. BRAME, late President of the Institution of Petroleum Technologists, delivered the first lecture of his course on "Motor Fuels."

The lectures will be published in the *Journal* during the summer recess.

TEN-VOLUME INDEX TO "JOURNAL."

The amalgamated Index to the *Journal of the Royal Society of Arts* for Vols. LXI-LXX (1912-1922) is now ready, and can be obtained free by Fellows of the Society on application to the Secretary, Royal Society of Arts, John Street, Adelphi, London, W.C. The price to non-Fellows is 2*s*. 6*d*.

PROCEEDINGS OF THE SOCIETY.

◆

FOURTEENTH ORDINARY MEETING.

WEDNESDAY, 11TH MARCH, 1925.

VISCOUNT BURNHAM, C.H., LL.D., in the Chair.

THE CHAIRMAN said it was a great pleasure to him, as President of the Anglo-Belgian Union, to take the Chair that afternoon. It was not necessary for him to introduce M. Cammaerts, who was a man of letters of European reputation. Nobody, he ventured to think, had expressed with equal grace and felicity in critical and descriptive writings, the spirit and genius of his country. The world had recently had from his pen a book which was in reality a spiritual guide-book to Belgium and her people. It would not be possible to have all that information in a paper, but doubtless a great deal would be heard of that which was embodied in the latest of his writings.

The following paper was then read :—

THE RECONSTRUCTION OF BELGIAN TOWNS.

By EMILE CAMMAERTS.

The work of repairing the damage caused in Belgium by the war may be considered to be practically accomplished. The cost of reparations, excluding all expenses incurred before the Armistice and the cost of the army of occupation, is estimated roughly at 19 milliard francs.(1) Of this sum, 5,700 millions have been spent on financial charges (taxes levied during the occupation, etc.), and over 1 milliard on personal indemnities (pensions, etc.). The rest has been devoted to reconstruction properly speaking : 4 milliards to the restoration of State property (including railways, waterways, roads, State forests, ports, etc.), and roughly 8 milliards to the restoration of private property. With regard to State property, normal conditions were already restored in 1920, while the end of the reconstruction of private property is now within sight. Out of 100,000 houses destroyed or badly damaged, 95,000 have been rebuilt, and, if we take into account 12,000 temporary buildings scattered over the country, we may say that the number of houses is larger now than before the war, even in the devastated districts. Out of 1,175 public buildings destroyed, 1,040 are now rebuilt. It is considered that 1½ milliards must still be spent to complete the work of reconstruction, the total cost of which can thus be valued at 13½ milliards.(2)

One of the conditions which has favoured this work is the prompt return to the devastated areas of their original population, including a great number of workmen whose labour could be utilised on the spot. The population of West Flanders, the province which suffered most from devastation, numbered 1,109,000 in 1914; it numbers to-day 852,000. Towns and villages which had

(1) £211,000,000 at the present rate of exchange.

(2) £150,000,000.

been razed to the ground, such as Ypres, Dixmude, Nieuport, Gheluvelt, Zonnebeke, Passchendaele and Lombaertzyde, have come to life again, and shelter from 70 to 90 per cent. of their pre-war population. The following figures, though somewhat out of date, may give an approximate idea of the progress accomplished :

Ypres	1914—19,000.	...	1924—13,500.
Dixmude	1914— 3,700.	...	1922— 1,800.
Nieuport	1914— 4,600.	...	1922— 3,600.

Some small towns lying on the border of the old battle-zone, have made up all arrears, and even show an important increase. This is the case, for instance, in Menin: 1914—18,300, 1922—17,500; in Roulers: 1914—26,200, 1922 25,900; and Furnes: 1914—6,500, 1922—8,000. The reclaiming of shell-pocked ground and of the marshes caused by the artificial floods of the Yser was completed last year, every one of the 90,000 hectares which the war had converted into a barren desert being now under plough or covered with rich meadows.

The period of transition being practically at an end, whether we consider housing, population, or agriculture, it may be useful to examine the results of the work which has been so quickly accomplished, and to see how far the process of restoration or reconstruction has been efficiently carried out. There is no doubt whatever that the wish so often expressed by the Belgian people to efface the last traces of the war has been realised. It has become more difficult to-day to discover signs of the recent devastation in Flanders than it was during the war to discover remnants of its former prosperity. For the last year or two some fortified works and trenches near Nieuport and Dixmude, carefully preserved as war curiosities, have attracted a good many visitors. They are small oases of war in a landscape of peace, comparable to the few patches of ground which could still be seen after four years of hostilities in a landscape blasted by shell-fire.

It is also evident that the purpose of the Belgian Parliament, expressed in the preamble to the 1919 Reconstruction Bill, has to a great extent been fulfilled : " Everything must be done in order to hasten the work of reconstruction and to put an end to the suffering of the unhappy people who have lost their homes, and have been obliged to appeal for hospitality in Belgium and abroad." The situation is perhaps not quite so satisfactory in some remote parts of the Namur and Luxembourg provinces as it is in Flanders, and in important towns such as Louvain, but, on the whole, the Belgian people may well be proud of the results achieved, in spite of the unsettled conditions and economic difficulties of the post-war period, and of the inadequate payments made by Germany (only 6½ milliard francs).(3) Most of the new houses are more comfortable and more solidly built than the old ones, and measures have been taken

(3) £72,000,000.

to ensure to their inhabitants a minimum of comfort and to avoid the springing up of new slums. This minimum was defined, in 1920, in instructions circularised by M. Renkin, then Minister of Economic Affairs, to the responsible authorities. All dwellings must include at least four rooms, and cover a total area of at least 160 square feet. The frontage must not be less than 14 feet and the height of the rooms less than 7½ feet. Foundations, drainage and sanitary installations must fulfil all the latest requirements of modern hygiene. It was, unfortunately, impossible strictly to adhere to these instructions in the last stages of reconstruction, owing to lack of funds, the State being obliged to supply the difference between the value of the old house and that of the new one; but they will give a fair idea of the spirit in which the work of reconstruction was carried out, and of the results achieved in the great majority of cases. It is enough to compare the neat brick houses, with cut-stone thresholds and window-sills, pitch-pine woodwork and sound foundations, with the old picturesque but frequently damp and insanitary cottages, to realise the progress accomplished, which repays the inhabitants for long months spent in huts and other temporary shelters.

These huts, which are now gradually being deserted for permanent dwellings, were of invaluable help during the period of transition, not only because they afforded a refuge to the *sinistrés*, but also because they provided housing for a great number of builders who flocked to the devastated areas. They were erected by the King Albert Fund, and from 1,600 in 1919, their number was raised to 10,000 in 1920, including schools, churches, town-halls, and hospitals. These huts can still be seen in the neighbourhood of all the devastated towns, but many of them are no longer inhabited by the *sinistrés*, but merely by people who are experiencing the difficulties of finding homes, owing to the general shortage of houses.

The question whether the work of reconstruction has improved or spoilt the picturesque aspect of Belgian towns and villages cannot be settled off-hand. There is a natural tendency to render reconstruction responsible for certain changes which could not possibly have been avoided. Part of the charm of old towns such as Ypres and Nieuport was due to the screens of old poplars and the patches of wood which surrounded them. Old trees could be seen even in the towns themselves, close to the church or along the bank of some canal. Those who know Bruges and have wandered along the Quai Vert will have no difficulty in realising what Nieuport, Ypres and Dixmude owed to the changing foliage of their trees. Time itself, by wearing out the bricks and covering stones and tiles with moss and lichen, had succeeded in softening the contrast of colour, and even in blurring, to a certain extent, the sharp design of some of the buildings. It was obviously impossible for the best architect to restore at once to Mediaeval and Renaissance cities the atmosphere provided by still water, great trees, weather-beaten tiles and pealing bells. If, therefore, we consider the work of reconstruction merely from the artistic point of view, we are bound to admit that a great deal has been lost which only time and the patient work of Nature can possibly restore to us; but, to be fair, we must also recognise that the efforts made, sometimes by private enterprise, but mostly under the control of the State, to preserve to the nation the finest and most inspiring of the buildings which had been razed to the ground, have not been fruitless, and that, in many instances, the general outline has been so conscientiously and scrupulously restored that we may foresee the time when future generations will take the same delight in these copies that we took in the originals in pre-war days.

A distinction should first of all be established between ordinary dwelling-houses which were of no particular architectural interest, and old public and private buildings which were considered to be worthy of notice. With regard to the first category, we have already alluded to the efforts made to prevent the rebuilding of slums. Another interesting initiative is the planning and building of new workmen's cottages, surrounded with gardens, on the model of the English garden-cities. Such *cités-ouvrières* have arisen since the war, notably in the neighbourhood of Ypres and in the new coal district of Limbourg. Some improvement is also noticeable in larger town houses, the plain monotonous frontage, so much favoured in the early nineteenth century, being replaced by the more picturesque and varied Renaissance gable. Some streets, in Louvain for instance, look certainly better to-day than they did in 1913. In other districts the control exerted by State and town architects has not been so stern or so successful. This is particularly the case in Dinant, where high three or four-storied buildings have been erected, marring the general aspect of the little town, which, in former days, seemed to crouch at the foot of the abrupt hills crowned by the citadel.

It is particularly in connexion with the restoration of historical sites and buildings that the results achieved surpass all expectations, owing doubtless to the anxiety of local and central authorities to preserve a national heirloom, and to give free scope to first-class architects who assumed full responsibility for the completion of their plans. These plans have invariably been drawn up on traditional lines, that is to say with the idea of reconstituting every feature of the old building. Whenever a new departure has been made, it has only been for the purpose of replacing some modern-looking edifices by new ones in the Renaissance style more in harmony with the chief buildings, so that, as soon as time and weather have exerted their beneficial influence, some sites will actually appear older than they did in pre-war days.

The little town of Furnes, whose population has considerably increased since the war, affords an excellent example of partial restoration. Of 1,500 houses 290 were destroyed; 325 have been restored or newly built since the Armistice. Any one standing to-day in the Grand' Place could scarcely realise that both the Renaissance Hôtel-de-Ville and the Palace of Justice had been damaged, that the tower of Saint-Nicholas had suffered from shell-fire, and

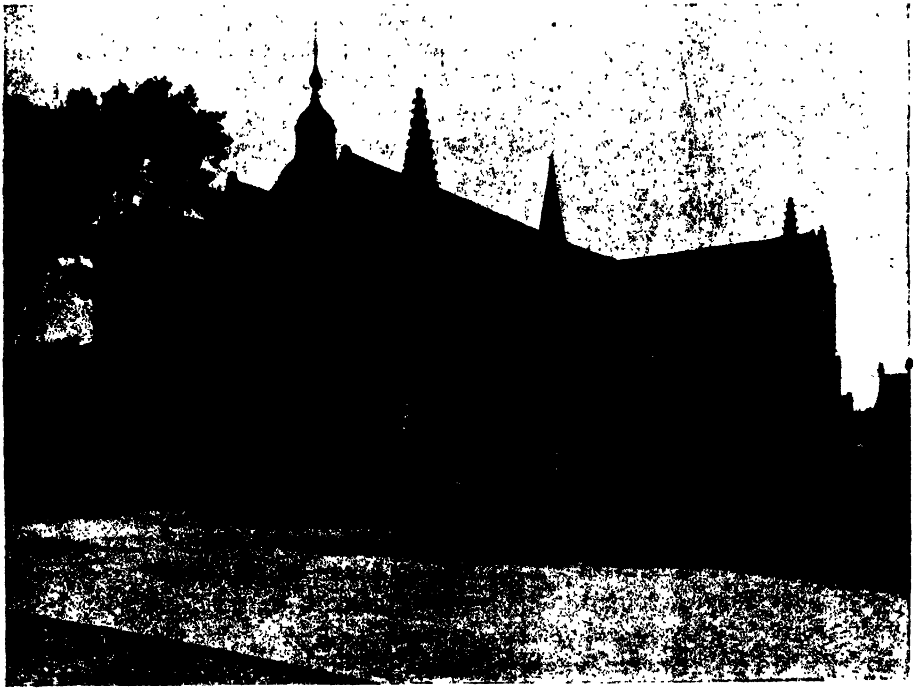

FIG. 1.—Nieuport: Church of Notre Dame, 1914.

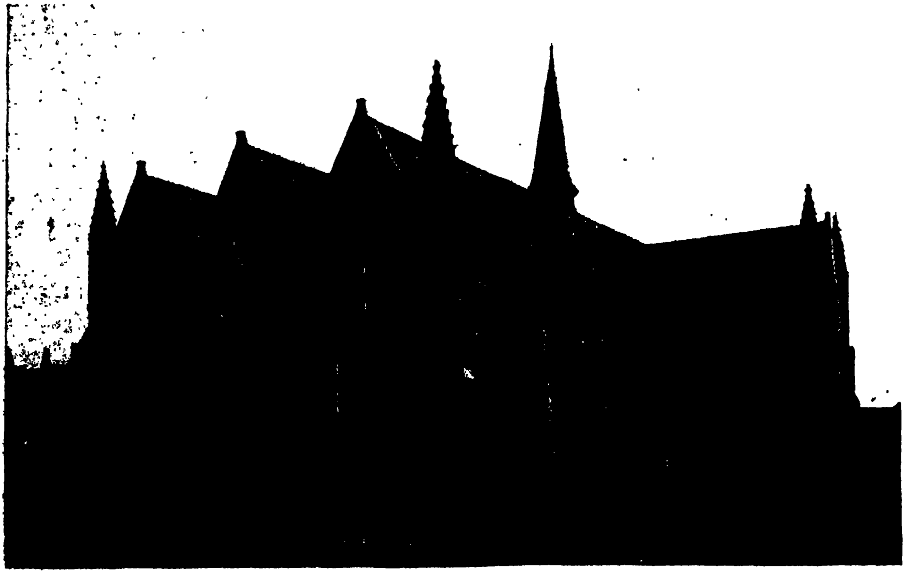

FIG. 2.—Nieuport: Church of Notre Dame, 1924.

that the houses on one side of the square had been demolished. Everything has been so carefully restored, even to the delicate tracery above doors and windows, that an expert might be led to suppose that only superficial repairs had taken place.

The situation at Nieuport is stranger still. The little town, situated close to the locks which commanded the flooding of the Yser, was completely wiped out. Of 961 houses, 415 had already been rebuilt in 1922, and their number must exceed 600 to-day. The 13th-century church has been entirely restored, under the supervision of the King Albert Fund, by its architect M. Viérin. Most of the material used was taken from the ruins themselves. The 15th-century Cloth-Hall close by has been restored with the same care, and some modern houses, which stood on the right, have been replaced by a 16th-century Town Hall, connected with the Cloth-Hall by a covered bridge. The pre-war Town Hall, now the Law-Court, in Louis XVI style, has been greatly improved in appearance by the addition of a new wing.

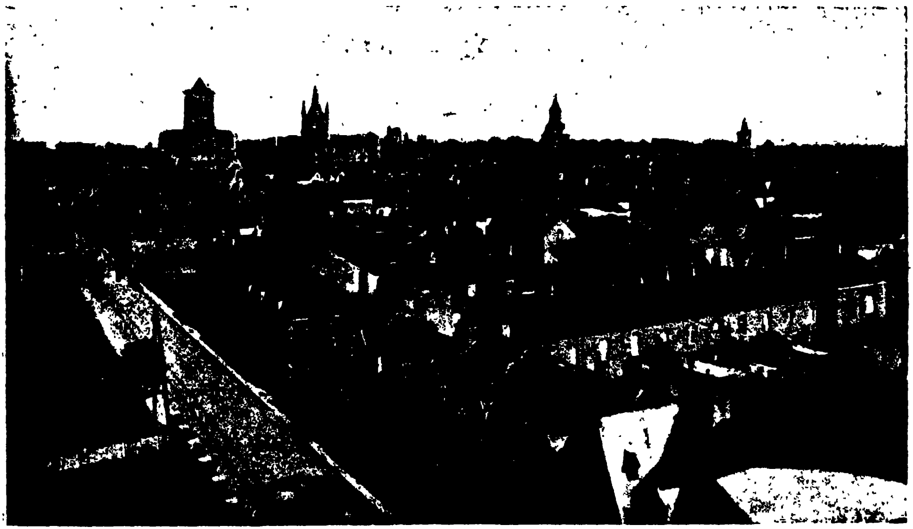

Fig. 3.—Ypres in 1914.

The present aspect of Ypres and Dixmude is not perhaps quite so satisfactory, because the work is not so far advanced and because the builders have not yet been able to remove all traces of the wreckage. The results already obtained constitute, nevertheless, a notable achievement. Of 3,780 houses destroyed in Ypres, 1,240 had already been rebuilt in October, 1924, and 1,250 more were in course of reconstruction, of which a great number must be completed by now. Twenty-eight public and historic buildings have been or are being restored. Among them we must include the Gothic churches of St. Peter and St. James, the Gothic Templars' House (which serves as Post-Office), the Châtellenie, the

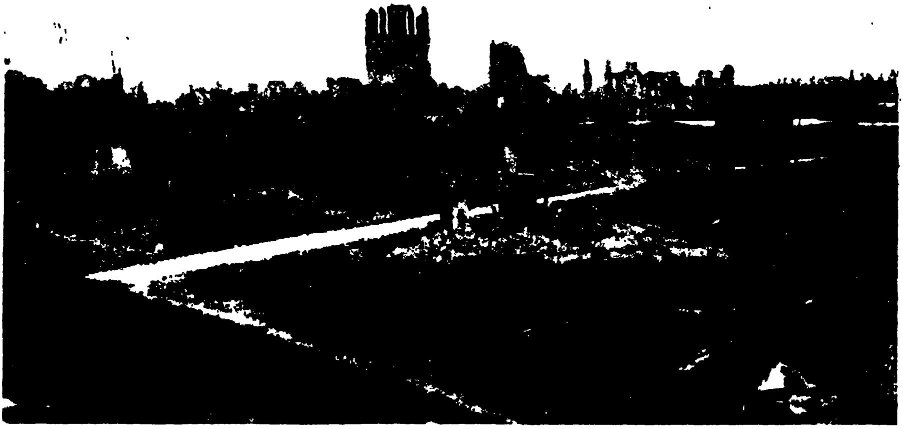

FIG. 4.—Ypres in 1918.

FIG. 5.—Ypres to-day.

two Renaissance houses known as the Hôtel de Gand, and the Hospice Belle, founded in the 13th century, which contained some valuable art treasures. The Boucherie (formerly a small museum) will be finished during the summer, and it is hoped that the great Cathedral of Saint-Martin, now surrounded by scaffolding, will be re-erected within three or four years. Practically all the restorations undertaken up to the present may be considered as entirely successful, owing to the scrupulous care which was taken only to depart from the original plan in very exceptional cases, and when the first building had been manifestly tampered with by former restorers. When we remember that, with the exception of one porch, the great Cathedral, over 300 feet in height and 150 feet in breadth, was reduced to a heap of wreckage, we shall realise that its reconstruction will test the art of the restorer and his knowledge of Gothic architecture, for the choir of Saint-Martin was begun in the early 13th century, while the lofty tower was only finished two centuries later. As for the Cloth-Hall, it is calculated that its complete reconstruction would cost from 50 to 60 million francs, and it is not likely that this will be undertaken for some time, if at all. The present ruins will no doubt be preserved carefully, and perhaps in later years one wing of the building will be rebuilt, if the need for a large hall of this kind arises.

About half of the 930 houses destroyed in Dixmude have been re-erected. The work has been delayed, owing to the fact that the German engineers had transformed the town into a maze of concrete works which had to be appropriated or destroyed. About 65,000 cubic feet of concrete had to be removed before the new town could be built. The restoration of the Gothic Church of Saint-Nicholas, undertaken by the church authorities, is almost completed; the Renaissance Hotel-de-Ville and the Gothic houses of the market place have also been restored; and it is expected that within a year the large market place, so characteristic of this small historical town, will resume its normal aspect.

This survey would not be complete if we did not mention the excellent work accomplished in Louvain, where the 1,100 houses destroyed have been re-erected, and where the Grand' Place, including the Church of Saint Peter and the houses surrounding the well-known Town Hall, has gradually resumed its former aspect.

The results achieved in the Liège, Namur and Luxembourg provinces, while highly satisfactory from a material point of view, have not always been so artistically successful. Whenever a historic building of some importance, such as the Gothic church of Dinant, and the fourteenth-century church of Spontin, has been restored, the same care has been displayed as in the northern provinces, but, owing mainly to lack of funds during the last stage of reconstruction, the State has not always been able to check the faulty taste of private owners. While in some cases the new buildings may be considered as an improvement, in other cases the pre-war aspect has suffered some disfigurement.

In attempting to draw general conclusions, we must not lose sight of the difficulties encountered by the authorities, owing to the failure of Germany to settle her reparations debt. As has been shown above, all plans had been laid down in order to prevent the rebuilding of any house which did not provide its inhabitants, however poor, with a minimum of comfort far above pre-war conditions. It is only through lack of funds that the State has not been able, in all cases, to face the additional charge involved—that is to say, the difference between the pre-war and post-war value of the house. It is the same reason which has not always rendered possible the substitution of a more artistic and expensive design to plans based on purely economical considerations. The results obtained from competitions between architects, organised in 1919-1920 in the devastated areas, were highly satisfactory. The winners of these competitions provided a series of designs, and the *sinistrés* were asked to substitute them for their own plans whenever the latter were deemed unsatisfactory, the difference in the cost being borne by the State.

The success achieved in so short a time is due to the methods adopted and to the spirit in which the work was carried out. Its direction was entrusted to five High Commissioners residing in Ostend, Bruges, Ghent, Mons and Liège, nominated by the King, and invested by him with exceptional powers until the completion of their task. These powers, which extended to all communes adopted under the law of April, 1919, combined the authority of governors of provinces, county authorities and communal authorities, as far as measures dealing with reconstruction were concerned. This method united the advantages of administrative centralisation, insuring celerity, with those of geographical decentralisation, insuring the close contact of the responsible head and of his assistants with the inhabitants of the zones affected, and avoided all difficulties resulting from red-tape and conflicting authority. A special body, the *Office des régions dévastées*, was created in Brussels, in order to ensure a prompt *liaison* between the five High-Commissioners and the Ministries concerned.

There seems to be no doubt that all those engaged in the work of reconstruction, from the Minister down to the last navvy, have been helped by their genuine desire to restore the land, to give back to the exiles their lost homes, and to efface, as far as humanly possible, the painful sight of the wreckage caused by war and enemy occupation. It is to this spirit more, perhaps, than to the sound methods adopted or to the skill of the architects, that Belgium owes her present position. It is no doubt owing to the same spirit that she has been able this year, for the first time, to balance her budget, in spite of reparations charges, owing to the heavy sacrifices made by the Belgian taxpayers. These sacrifices and this labour will not be in vain if the people obtain a sufficient guarantee of security to allow them to believe that the aggression which destroyed their towns and ruined their prosperity will never recur, and that the churches and town-halls so patiently rebuilt will not again be subjected to wanton destruction.

DISCUSSION.

His Excellency the Belgian Ambassador was sure every one had listened with as much interest as himself to the very interesting lecture M. Cammaerts had given. He had shown in beautiful English what might be called the resurrection of Belgium—its reconstruction. That reconstruction had gone so far that recently an English tourist came back rather disappointed, and said he had been there to see traces of the war and the devastation, but saw nothing but a desert of peace., If Belgium could return to the new state of prosperity, or apparent prosperity when the bill came to be paid the devastation would no more be there, but there was still a great deal of devastation in the exchange, and even more devastation in the pockets of the taxpayer. Nevertheless, the Belgians were doing their best, and he was sure that little by little they were coming back to what he might call the pre-war state. To reach that state it was necessary to have the assistance of the very able and distinguished statesmen and financiers who had assembled in conference in London last August, and who had succeeded in putting in action what was called the Dawes plan. Certainly miracles were not to be expected from that plan, but no doubt Belgium would get a very respectable amount out of it.

As M. Cammaerts had said so truly, if Belgium were reconstructed that reconstruction must last. He had admired the people in Italy who were building houses with gardens on the dead lava, always liable to be overwhelmed by the eruption of liquid fire, and an analogy might be drawn with Belgium, who in future must avoid the lava of war with its consequences. For that purpose they must base their hopes on the very able statesmen to be found in England and amongst the Allies, who would discover, he was sure, some way of preventing war—not for ever, because he thought war was inherent in human nature—but at least, perhaps, for some centuries. It was to be expected that out of their work at the League of Nations, and also he hoped from the Treaties and Conventions which would be signed between the nations who were really in love with peace, peace would be abiding.

Before concluding he wished to thank M. Cammaerts for his eloquent description of the reconstruction of Belgium, and he wanted also to thank Lord Burnham who had been kind enough to take the Chair. He knew how busy Lord Burnham was and how much was expected from him, but as he had already told his Lordship, he thought he had already solved the problem of ubiquity, because he found him everywhere where there was something good, kind, and noble to be done.

THE CHAIRMAN (Lord Burnham) said he was very grateful to the Ambassador for the kind way in which he had spoken of him. It was not as difficult as might be thought to be one of the busy-bodies of London life. In his touching and eloquent address M. Cammaerts had ended on a note of national tradition. Most of the evils of the world arose from a false tradition, and no country could attain a real nobility of character until it had a great tradition, founded upon national ideals which were derived from an historic past, and attached by inextinguishable hopes to the future that lay before it. Nobody had shown more conclusively than M. Cammaerts in his writings what the tradition of Belgium was worth, a tradition slowly and painfully formed through centuries of struggle and even anguish, but which had withstood the test so marvellously well when the last trial was imposed upon it. He agreed with M. Cammaerts in thinking that, while paying a just tribute to the fortitude and heroism of the Belgian people during the occupation, not enough was said or thought of the magnificent endeavour and resolve of the Belgian people to be the first in Europe to attain a complete moral and material reconstruction after the war. Having seen it with his own eyes, he could say, *Credo quia impossibile*. It was difficult for any one who had not seen it to call up the reality of things as they were, and M. Cammaerts had to be thanked for having enabled the audience that evening to get some idea of the state of affairs.

He was over in Belgium in 1919 for the first time after the war, and it was wonderful then to see what had been done to bring back the cultivation of the land to something approaching its former productiveness. Since then he had been two or three times to most parts of the country, and he could say unhesitatingly that there was no place in the devastated regions, or even regions badly affected by the war, in which so great an effort had been made with so large a measure of success. What it meant to the Belgian people was best realised by one fact alone. He had to do with the consideration by the International Labour Conference of the League of Nations of what was called the 8-hours convention, limiting the trades of the world to an 8-hour day. He believed it was adopted by the Belgian Parliament, but it could not be enforced everywhere there because the people insisted upon working more than 8 hours. M. Cammaerts had spoken of the new style being called the reconstruction style. He rather quarrelled with the Ambassador because he anticipated him in giving it another name, when he said it ought to be called the resurrection style! He would use that phrase just as the Ambassador had used it, and could assure him and M. Cammaerts that nothing was better calculated to give this country the right spirit in future, in face of the manifold difficulties and after so great a disaster as the war, than to pay regard to the manner in which Belgium was showing the will to restoration, moral and material, and was determined she would prove her right to that glorious independence which she won over the centuries, and which was recognised not to be a matter of treaties, but inalienable from the character of the nation. It was for all those reasons that they had been so glad that evening to have had an account of what had taken place from so accomplished a master as M. Cammaerts, and he might be allowed to join the Ambassador in expressing the warm thanks of all who were present for the lecture he had given. He was sure every one had profited very much from the hour spent in that beautiful hall.

NOTES ON BOOKS.

A HISTORY OF BLEACHING. By S. H. Higgins. London: Longmans, Green and Co. 10*s*. 6*d*. net.

We have here a somewhat detailed account of bleaching as applied to "Manchester Goods," that is to say, mainly cotton with linen as secondary; but the very numerous and varied applications of bleaching, as of oils, fats, waxes, shellac, flour, silk, and in that chief or paramount aspect, the production of the present-day paper-pulp, are scarcely touched on. Thus it will be understood that the history is sectional rather than general, indeed, to judge by the preface, the book appears to have been written with the aim of interesting and instructing those engaged in the bleaching and dyeing aspects of the Manchester trades.

Mr. Higgins gives us no index; hence many interesting details may be almost lost to a studious reader who wishes to turn back and compare. But perhaps the portion of the book which is least deserving of commendation is Chapter I., Early Times, pp. 1 to 8. Here Pliny is mentioned, and our author gives us his English version of what Pliny says, but there is no reference to book and chapter of Pliny, or to page and line of a printed edition. Further, on page 8, Mr. Higgins gives us a group of sketches, evidently based on some of the paintings in colours found on a pier of the fullonica at Pompeii, but since removed to the museum at Naples. Mr. Higgins, owing possibly to hasty sketching of the somewhat disintegrated originals, makes the tunic which hangs over a pole and is being brushed or carded, look as if it were a strip of printed Manchester goods. This seems to be a rather unsatisfactory rendering of the original picture.

Any one wishing to see other sketches from the paintings, together with particulars as to the colouring, and a detailed account of fulling as distinguished from bleaching, can refer to pp. 144-148 of the second volume of "Pompeii," published by Knight, Vol. I., 1831, and Vol. II., 1832.

STEVENS' ELEMENTS OF MERCANTILE LAW. Seventh Edition. By Herbert Jacobs, B.A. London: Butterworth & Co.

This well-known work appears to be in great demand by students and others, for although a reprint of the 6th edition only appeared in 1922, a fresh edition has been already called for. This 7th edition has not only been brought up-to-date in the usual way, but the larger size of the book, which now allows sufficient space for side-notes, is a great improvement. The text has been divided into more frequent paragraphs and this, together with the heavier type used for headings and sub-headings, makes the new edition more convenient and attractive to students and others consulting it.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock:—

APRIL 29.—ANDREW BALFOUR, C.B., C.M.G., M.D. (Edin.), B.Sc., D.P.H., F.R.C.P.E., "The Trend of Modern Hygiene." SIR GEORGE NEWMAN, K.C.B., M.D., D.C.L., F.R.C.P., Chief Medical Officer, Ministry of Health, will preside.

MAY 6.—AIR VICE-MARSHAL SIR WILLIAM SEFTON BRANCKER, K.C.B., A.F.C., Director of Civil Aviation, Air Ministry, "Commercial Aviation." HIS GRACE THE DUKE OF SUTHERLAND, President of the Air League of the British Empire, will preside.

MAY 13.—(Joint Meeting of the Royal Society of Arts, the Royal Aeronautical Society, and the Anglo-Batavian Society.) THOMASSEN À THUESSINK VAN DER HOOP, "The Flight to the Netherlands East Indies." (The paper will be read in English). MAJOR-GENERAL SIR FREDERICK SYKES, G.B.E., K.C.B., C.M.G., M.P., will preside.

MAY 20.—PROFESSOR JOHN AMBROSE FLEMING, M.A., D.Sc., F.R.S., "William Sturgeon and the Centenary of the Electro-magnet." ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council of the Society, will preside.

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

MAY 8.—SIR GILBERT T. WALKER, C.S.I., M.A., F.R.A.S., Sc.D., Ph.D., F.R.S., "Indian Meteorology."

MAY 22.—SIR ALFRED CHATTERTON, C.I.E., B.Sc., Assoc.M.Inst.C.E., "The Industrial Progress of the Mysore State."

JUNE 12.—BRIGADIER-GENERAL SIR PERCY M. SYKES, K.C.I.E., C.B., C.M.G., "The Heart of Asia and the Roof of the World."

DOMINIONS AND COLONIES SECTION.

Thursday afternoon, at 4.30 o'clock:—

JUNE 18.—**HON. W. G. A. ORMSBY-GORE, M.P.**, Under Secretary of State for the Colonies, " East Africa."

HOWARD LECTURES.

Monday evenings, at 8 o'clock:—

PROFESSOR JOHN SAMUEL STRAFFORD BRAME, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, " Motor Fuels." April 27, May 4.

SYLLABUS.

LECTURE II.—APRIL 27TH.

Physical properties of motor spirit, motor benzole and power alcohol in relation to performance. The fuel-air mixture.

The combustion of motor fuels. Researches of Watson, and Fieldner and Jones.

LECTURE III.—MAY 4TH.

The combustion of motor fuels. Compression and efficiency. Pre-ignition and detonation. Researches of Ricardo and Midgley and Boyd. Anti-detonation efficiency of fuel components. Special " anti-detonating " agents— " ethyl gas." Mixture fuels. Problems of production. Practical results.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

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MONDAY, APRIL 27..Geographical Society, 135, New Bond Street, W. 8.30 p.m. Mr. C. P. Skrine, " The Alps of Kungur."

Architectural Association, 34, Bedford Square, W.C. 8 p.m. Lecture by Mr. F. Bramley.

Philologie, Sciences et Beaux-Arts, Société Internationale de, 8, Taviton Street, W.C. 3.30 p.m. Prof. Lafou carde, " Modern French Poetry."

araday Society, at the Chemical Society, Burlington House, Piccadilly, W. 1. Mr. A. E. Ollard, " Adhesion of Deposited Nickel to the Base Metal." 2. Mr. H. Sutton, " The Brittleness of Zinc Plated Steel." 3. Mr. W. A. Naish, " The Partition of Silver between Lead and Zinc." 4. Mr. H. J. Poole, " The Elasticity of Gelatin Jellies and its Bearing on their Physical Structure and Chemical Equilibria." 5. Mr. E. K. Rideal, " A Note on the Reduction Potential of Dicyanquinhydrone." 6. Mr. D. B. Macleod, (i.) " On some Physical Properties of Water." (ii.) " On the Relation between the Viscosities of Liquids and their Molecular Weight."

University of London, King's College, Strand, W.C. 5.30 p.m. Prof. R. Chambers, " Recent Advances in the Study of Living Cells." (Lecture I.) (Lectures II. and III. on 28th and 29th April).

London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. Mr. P. J. N. Baker, " The Reconstruction of Austria." (Lecture I.)

East India Association, Caxton Hall, Westminster, S.W. 3.30 p.m. Mr. F. H. Brown, " Indian Students in Great Britain."

TUESDAY, APRIL 28..Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 7 p.m. Mr. M. Platt, " The Accessibility of the Pleasure Car Chassis."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. C. Friese-Greene, " Latest Improvements in the Friese-Greene Colour Process for Kinematography."

Physiology, London College of, 8, Taviton Street, W.C. 8.15 p.m. Dr. H. M. Leon, " Physiology under the Arabs."

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. J. Barcroft, " The Effect of Climate on the Circulation." (Lecture II.)

University of London, at the London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. Mr. J. F. Rees, " Some Aspects of British Foreign Trade in the Eighteenth Century." (Lecture I.) (Lecture II. on April 29th.)

WEDNESDAY, APRIL 29..University of London, King's College, Strand, W.C. 5.30 p.m. Sir Havilland de Sausmarez, " The Extra Territorial Court."

THURSDAY, APRIL 30..British Architects, Royal Institute of, 9, Conduit Street, W. 5 p.m. Mr. J. D. Batten, " Mural Painting."

Child Study Society, 90, Buckingham Palace Road, S.W. 5.30 p.m. Annual Meeting.
6 p.m. Dr. C. W. Kimmins, " Progress of Child Study in America."

Brewing, Institute of, (Yorkshire Section), Queen's Hotel, Leeds. Paper by Mr. F. M. Mayard.

Royal Institution, Albemarle Street, W. 5.15 p.m. Mr. F. K. Ward, " Plant Hunting on the Roof of the World."

FRIDAY, MAY 1..Philological Society, University College, Gower Street, W.C. 8 p.m. Anniversary Meeting.

Philologie, Sciences et Beaux-Arts, Société Internationale de, 8, Taviton Street, W.C. 8.15 p.m. Major Rigg, " Charles Dickens and His Works."

Photographic Society, 35, Russell Square, W.C. 7 p.m.

Royal Institution, Albemarle Street, W. 9 p.m. Sir William Bragg, "Crystalline Structure of Inorganic Salts."

University of London, King's College, Strand, W.C. 5 p.m. Dr. A. W. Rogers, " Physical Features of South Africa in relation to its Geological Structure and History." (Lecture I.)
5.30 p.m. Prof. F. J. Cole, " The History of Protozoology." (Lecture I.)

SATURDAY, MAY 2..Royal Institution, Albemarle Street, W. 3 p.m. Mr. W. P. Pycraft, "Use and Disuse—Effect of Structure of Animals." (Lecture II.)

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No. 3780 VOL. LXXIII.

FRIDAY, MAY 1, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, MAY 4th, at 8 p.m. (Howard Lecture). PROFESSOR JOHN SAMUEL STRAFFORD BRAME, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, " Motor Fuels." (Lecture III.)

WEDNESDAY, MAY 6th, at 8 p.m. (Ordinary Meeting.) AIR VICE-MARSHAL SIR WILLIAM SEFTON BRANCKER, K.C.B., A.F.C., Director of Civil Aviation, Air Ministry, "Commercial Aviation." HIS GRACE THE DUKE OF SUTHERLAND, President of the Air League of the British Empire, will preside.

FRIDAY, MAY 8th, at 4.30 p.m. (Indian Section). SIR GILBERT T. WALKER, C.S.I., M.A., F.R.A.S., D.Sc., Ph.D., F.R.S., " Indian Meteorology." SIR REGINALD A. MANT, K.C.I.E., S.S.I., will preside. Tea and coffee will be served in the Library from 3.45 p.m.

EIGHTEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 22nd, 1925. MR. EMERY WALKER, F.S.A., in the Chair.

The following candidates were proposed for election as Fellows of the Society:

Dickson, Raynes Waite Stanley, Melbourne, Australia.
Dowling, Henry George, London.
Harding, Pearcy S., Sutton, Surrey.
Lieb, Dr. John William, New York City, U.S.A.
Lightfoot, Vernon Robert, Widnes, Lancs.
Manson-Bahr, Philip, D.S.O., M.D., F.R.C.P., London.
Norén, Herbert, Walvis Bay, South Africa.
Richards, Francis William, London.

The following candidates were duly elected Fellows of the Society:—

Dodd, Edgar, Compton, Wolverhampton.
Nicholas, George Augustus, London.

Phillips, Stanley Tysoe, London.
Satchell, Octavius, London.
Varley, Lieut.-Commander Cromwell H., R.N. (ret.), D.S.C., London.
Ward, Melville Seth, F.R.I.B.A., London.

A paper on "Bookbinding" was read by Mr. CEDRIC CHIVERS, J.P., Mayor of Bath.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

FIFTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 18TH, 1925.

MR. DUDLEY JOHNSTON, President of the Royal Photographic Society, in the Chair.

THE CHAIRMAN said that though cinematography played a great part in the world to-day, it was as yet only in the experimental and embryonic stage. So far as the entertainment side of it was concerned, a considerable amount of work had been done and research carried out, but that was only a minor part of the work of which cinematography was capable. Its applications to the study of science, in particular, had hardly yet been exploited, though by means of the slow motion picture problems were already being studied which a year or two ago it would have been impossible to investigate. The artistic possibilities of cinematography, moreover, had as yet hardly been touched.

Beautiful though the monochrome picture, obtained either by cinematography or still photography, undoubtedly was, it could be made yet more interesting and beautiful by the addition of colour. Colour was the lodestone which all photographic workers were seeking at the present time. A direct colour process, the only perfect one, was not yet in sight, but many forms of additive colour had been invented and added greatly to the interest of the pictures in which they were applied. Additive colour processes depended for their effect on an illusion.

The lecturer had invented a process which was amongst the most beautiful and the most promising of all, and had the additional advantage of being commercially possible. There were methods by which colour could be applied to cinematography which were in some respects, perhaps, still more beautiful, but they were too complicated and therefore not commercially possible.

Mr. Claude Friese-Greene was the worthy son of an illustrious father. Forty years ago Mr. Friese-Greene, senior, showed the first moving pictures seen in this country, and from that time onward he spent his life and fortune in the invention and development of the cinematograph picture.

The paper read was :—

THE FRIESE-GREENE PROCESS OF COLOUR CINEMATOGRAPHY.

By CLAUDE H. FRIESE-GREENE.

Twenty years ago I was attending a boarding-school. I ought to feel proud at the thought that I was only absent from school once during my terms, and that one time I mention because it was the first that I can remember definitely of the beginning of colour cinematography. The occasion was a request by my father to photograph me by an invention of his that seemed to show promise from a colour point of view, and I can remember very distinctly being dressed in a little sailor costume and waving a union-jack from side to side. Strangely enough, in later years, this particular picture played a very important part in helping us to establish dates as to some of the first basic conceptions of colour cinematography. Many years have passed since then, and many minds have striven to find a solution that would make colour cinematography a commercial and practicable proposition. I, as a boy in my teens, even then gave a considerable amount of thought to it, and since the war I have been able to improve on the basic efforts of my father.

First of all, I think it may be helpful for us to consider for a moment the benefits to mankind that motion pictures in colour will give.

Personally, my first thought is the fact that colour is closer to nature; it will help us to visualise scenes in their true perspective, and enable us to obtain and create atmosphere. Another great advantage of colour is from the educational point of view; in botany, for instance, the beauty of a flower is not only in its form but also in its colour. Therefore, I feel that the object we are striving for is one that is worth while; one that will be a service to the world when we succeed in making colour films as general as black and white on the screens of all the nations.

Now, granted that our object is worth the effort that many have devoted to it, I would just explain to you, briefly, methods that have been adopted and the method that I am adopting. Apart from the experiments of great scientists of the past—men who discovered the substance that was sensitive to light, the chemicals that made it possible to develop the latent image upon a sensitive surface; men who have striven to probe into the theory of colour and what it consists of; men who have discovered the sensitizing dyes that have made it possible to reproduce in monochrome the different gradations of colour waves, all a wonderful evolution that brings us to this present time,—there have been two main principles utilised to reproduce colours in motion pictures, one a subtractive method, the other what we term an additive method. In simple language, the subtractive method is one whereby the colour result is finally completed on each single picture. By the additive method the final colour result is obtained optically. I have experimented on both these principles, and although some beautiful results can be obtained by it, I am convinced that commercially, up to the present, the subtractive method is not practical, owing to the fact that colour dyes for dye-toning, etc., have not yet been brought to perfection; and, mainly, that the film itself is a substance that is not consistent, because, owing to its shrinkage, it is impossible at any time to be certain that you can superimpose two or more pictures, on top of each other in dead register. Therefore, the films you are going to see this evening will be ones that are produced by an additive method.

Now what is the additive method? Putting the whole theory into a very few words, I think it can be explained like this.

We will imagine for a moment the spectrum, with which, no doubt, you are quite conversant, it being simply white light broken up. We have a negative, which is sensitive to colour. In the camera I utilise an attachment that intercepts the light rays between the lens and the film. This attachment consists of colour filters, one picture being exposed through a filter which absorbs, for argument's sake we will say, half the spectrum, and transmits the other half. The next picture transmits that which has been absorbed, and absorbs that which has been transmitted in the previous picture, so we really, roughly speaking, break the spectrum in half in the negative. It is apparent, then, that I am using only two colours, which, of course, have certain limitations. I have experimented with three colours and obtained successful results, but, unfortunately, it is not on a basis that would be commercially sound at present. The negative is developed and a positive print taken therefrom by the usual method. Now, on this positive the picture which has been photographed through the filter which has transmitted, we will say, colours on the red side of the spectrum, is coloured wholly with a red absorption dye, and the next picture is coloured with a blue absorption dye, and alternately so on throughout the film. The positive is then projected by an ordinary projecting machine. The whole theory of ordinary black and white motion pictures is based upon persistence of vision, and for my colour work I also, apart from the fact of motion, utilise the principle of persistence of vision to give my colour effect. Therefore, what has really happened, in a very few words, is that in the negative the spectrum is broken in half, and in the positive the spectrum is, by persistence of vision, mended again.

Now I hope you have, briefly, the principle under which the pictures you are now going to see are obtained, and after you have seen the pictures I will, with your permission, take you as far as I can in the shortest time possible, into the details and improvements that have been effected to make it possible for me to show what you are now going to see.

I would like you to carry in your minds that the cost of the prints of these films is practically the same as that of black and white, as is also the time in turning them out.

[Here a number of films were exhibited to illustrate the process.]

Having now shown the pictures I will try to explain to you the process.

I told you that on the camera I made use of an attachment which intercepts the light rays between the lens and the film. Now the constitution of that attachment is in form simply a rotating disc having two apertures, and travelling at half the speed of the ordinary camera shutter, so that each alternate picture is impressed with the different light sensations necessary. This is effected by one aperture being filled with a light transmission filter which transmits colours on the red side of the spectrum.

Of course, many colour filters have been used before, and are still being used, but one has to consider the sensitivity of the panchromatic emulsion which, although brought up to a very high degree of perfection, is not perfection itself. One also has to consider the rapidity of exposure necessary for photographing motion pictures, and bearing all these points in mind, I have ascertained that the best colour filter at present, which gives me the finest gradations and the maximum amount of exposure, is the combination of two colour dyes, one rose bengal and the other a flavazine T. This gives me, also, if exposure is made fairly correct, a very good colour cut-out. Now in the other aperture I utilise strangely enough, and against all theory of colour, a combination of white light with a colour phase on the red side of the spectrum also. This is quite new and very few of the pictures you have seen to-night were taken by this method. I think one of them was the picture of Miss Flora Le Breton, the majority of them having been photographed under my old patent, consisting of white light and a blue-green phase. However, I am sure you will appreciate, the white light having passed all colours, and the blue having been absorbed in the red picture, the reason why I secure blue cut-outs on the blue-green picture. My reason for having resorted to the use of a colour on the red side of the spectrum in the blue picture is the endeavour to get a green cut-out on the blue-green picture; the taking filter is, in fact, a pale yellow, transmitting the greens in nature; green, as you know, being practically the centre of the spectrum. I dare say many of you can remember the tendency of all two-colour processes to reproduce green as brown. Strangely enough, the use of red and white not only benefits from this point of view, but also benefits in the projection of our films from the positive end.

Now let us see what we have actually got up to the present. It is an attachment to the camera, being in form a disc with two apertures. One aperture is entirely filled with a colour filter passing light from the red side of the spectrum; the other aperture is partly filled in with some opaque material, leaving a small white opening in combination with a small portion of filter also passing light from the red side of the spectrum. When this attachment is fitted to the ordinary motion picture camera everything is ready to expose the negative.

I think, while we are dealing with the negative, we might just touch on the best exposure and class of light to photograph in. I have found that, undoubtedly, the best light to expose in is, if I may put it this way, a subdued bright light, which results in a very fine graded negative, the shadows on which are not too harsh. The lens aperture in such class of light is stopped down to about F.8. Of course, it is possible to photograph quite successfully in strong sunlight or less brilliant light; that, I think, is one of the advantages of the process. To photograph in artificial light it is only necessary slightly to adjust the balance between the respective apertures in the disc.

We will assume that we have now taken a picture. The negative being panchromatic is developed in precisely the same way as black and white negatives, with the exception, of course, that it must be developed with a safe light, or, better still, in total darkness, which in practice we always do ourselves, having first taken a test and ascertained the time necessary. It is dried and a positive print taken off on the usual standard printing machine. Instead of dyeing or staining the positive, we put it through a machine by which each alternate picture is stained. The picture which has been exposed entirely through the light filter, which we will call the red filter, is coloured approximately an orange-red; the picture which has been photographed through the combination of white opening and red phase, which we will call the blue filter, is stained approximately a blue-green. The positive is then ready for projection and is projected by a standard projecting machine with the results that you have already seen.

A brief outline as to why the different colours present themselves in their correct places is perhaps worth a few moments.

Imagine that we have taken a negative of some red, white and blue stripes; let us examine closely the results of just the red stripes first. On the picture photographed through the red filter the red stripes will have been transmitted, and, therefore, exposed, the density being quite opaque. On the next picture, having been photographed through the blue filter, the red stripes will not have photographed to such a degree of density, appearing practically transparent. A positive print is taken from the negative, which we then examine. The red stripes photographed through the red filter that appeared opaque will be reversed to transparent, and in the picture of the red stripes photographed through the blue filter they will be opaque.

After having stained the positive print with the orange-red and blue-green—being careful that the correct picture is stained the correct colour—in the case of the red stripes the picture where they appear transparent will be stained orange-red and where they appear opaque blue-green, and so on, alternately throughout the length of the positive print.

The finished positive film is then put on an ordinary projecting machine. We know that only one picture is actually screened at a time, so that when the projection light is passing through the picture of the red stripes that has been stained orange-red, and knowing that the red stripes are transparent in this picture, we shall get a reddish light thrown on the screen where the stripes should be red. The next picture, stained blue-green, follows; but in this picture the red stripes being opaque, the blue-green light cannot penetrate on to the screen, so that directly a certain speed is attained to enable persistence of vision to do its work, we see the red stripes reproduced. In the case of the blue stripes it is just the reverse; in the positive, the picture stained blue-green, we shall have the blue stripes transparent, and in the picture stained orange-red, the blue part will be opaque.

Regarding the white stripes, they should be of equal transparency in each picture, and as you know, when complementary colours are displayed rapidly before the eye they reform back into white.

To go a point further into this matter, it is well to try and visualise the faults of previous efforts by this principle. The first objection was, I think, the tiring of the eyes, owing to the fact of what we might term colour pulsation due to the great amount of vividness of colour. Then, secondly, the speed of running, and, thirdly, what we call colour fringing. Colour fringing was detected by watching closely quick movements. When apparent it caused a red and green edging round the particular object that was moving.

Regarding colour pulsation, I have reduced that to, I think, a negligible quantity by continuous experiment and ascertaining the best combination of colour filters to use, my main object always being to try to obtain the maximum amount of colour with the minimum amount of colour cut-out. This has made it possible to get the more or less delicate colours which you have just seen. This point has also assisted the speed of running, owing to the fact that by the method I am now using it is so simple to obtain a perfect colour balance.

Regarding the projecting speed, I have already mentioned one reason why this is assisted, and the other reason is purely owing to the fact that the colours I use in staining the film are colours the luminous values of which I have endeavoured to balance as nearly as is possible. An automatic machine is now in course of manufacture which will make it possible for me to create a balance of luminous values with more accuracy, and should make the staining always consistent. The speed of running in many scenes is from 10 to 12 minutes per 1,000 feet; this speed is by no means unusual in the picture theatres of to-day, 12 minutes, as a matter of fact, being generally accepted now as normal speed of projection. I have, therefore, reduced the speed to well within the scope of all ordinary picture theatres.

Regarding colour fringing, I have reduced that to a minimum by following one exposure after the other as quickly as possible, and I think you will agree from the pictures you have seen to-night, that, although fringing is probably there, it is not apparent to the eye.

It is an interesting point to know that the manufacturing cost of positive prints by this process does not work out at more than ½d. per foot over and above the cost of black and white; in fact, it is less than that.

I am hoping that before long many films produced by this method will be on the screens. We have already started.

I should like, before concluding, to touch for one moment on the influence of the Motion Pictures.

There is no doubt that the invention of cinematography has brought an amusement to those people who, in time gone by, had no entertainment of this class within their means. Since cinematography has developed it has made it possible for us to not only give that class of people entertainment, but, if desired, enlightenment as well, and the industry has grown so much that it is now the world's most popular mode of entertainment. I have just recently returned from America, and, as somebody put it to me, the general life of the American in his time of relaxation consists mainly of two things, automobiles and the "Movies." I think that gentleman was fairly correct, from what I observed.

The American public are very keen on motion pictures, and their interest is cultivated by the Press to a much greater degree than is the case in any other country, which is, no doubt, one of the reasons why Americans are so far ahead of anybody else.

I am sure you will all agree that the motion pictures undoubtedly reach the masses of the peoples the world over. That being so, there is no doubt that the nation which dominates the screens can influence the minds of the masses consciously or sub-consciously, for better or for worse. Surely then, it is incumbent upon us, the heart of the British Empire, at least to endeavour to produce good pictures for the benefit of our Empire, the greatest in the world. Let us depict the ideals that have in the past made us what we are to-day. Let us show our cousins in Australia, Canada, New Zealand, Africa, and all our Colonies at the very least the Old Mother Country and the ideals that are best in us.

Up to the present some of our Colonies have never seen a film produced in this country or by this country. Surely this is serious, because you can see just as well as I can the great influence the motion picture has. In the majority of cases, I do not think the influence has been harmful, but the danger is there, and we must look to it, and if the need ever comes, we, the British industry, must be in a position on the world's market to hold our own, so that we may counter any propaganda that may be against the good and peaceful working of the world, or against the interests of our Empire.

I would not like this occasion to pass by without referring to the great work of my father, upon whose basic efforts I have already told you I have been able to improve. There is no doubt whatever that it was from his brain that cinematography, apart from colour, as we know it to-day has evolved, and now that we have realised the world-wide magnitude and importance of the motion picture industry, we can, at least, feel proud that it was the invention of an Englishman, who was a member of this great Society.

DISCUSSION.

THE CHAIRMAN said he was sure everyone would appreciate the beauty of the results the author had obtained. The great test of colour from an artistic point ot view was the production, not of vivid hues, but of the greys. The author's process appeared to have considerable possibilities in that respect, because in certain of the pictures—particularly that showing the cygnets—the greys were very beautiful. In some of the other pictures there might be a preponderance of bluish greens, but on the whole, particularly in view of the fact that the effects were produced by two colours only, it was wonderful what had been achieved.

Mr. W. E. L. Day said all Englishmen would be proud of the fact that the world owed its knowledge of commercial cinematography to this country. It was in this country that the whole of the basic principles were laid down. After the wonderful paper which Dr. Roget read before the Royal Society, Mr. William Friese-Greene in 1889 solved the problem of commercial cinematography, and his patent was the first in the world, and had been upheld the world over as the master patent for cinematography.

His colour research, as the author had stated, was certainly the first colour process to be patented for cinematography, and it was, therefore, hardly surprising that the son of so illustrious a father should provide the first commercially possible method of colour cinematography. The films which had been shown that evening afforded sufficient proof of the fact that a real commercial colour process was now possible. The fact that it could be produced at an extra cost of less than a farthing a foot over the ordinary black and white film spoke volumes for the future of picture production. The colour process would be of great value for showing mannequin displays, and the method was especially valuable, because it could be shown with an ordinary projector, and did not require an extra attachment. It could be used in conjunction with ordinary monochrome films.

A Member of the Audience asked whether the process involved the employment of a lens of very large aperture.

Mr. Friese-Greene said it did not. The reason was that light transmission filters were used. The panchromatic emulsion used nowadays had improved a great deal. In a subdued bright light—a sky with one gathering of cloud, where there was a certain amount of shadow—and with the filters he used, the ordinary lens, which usually worked at f/3.5, could be shut down to f/8.

Mr. Colin Bennett said he had worked with the late Mr. William Friese-Greene in 1912, and remembered some of that gentleman's earlier attempts, which were by no means helped by the fact that the technical Advisory Committee which overlooked them, consisted of a wholesale clothier, a well-known manufacturer of jam, and a cotton spinner. These gentlemen, finding they could not adopt the same business methods in regard to Mr. Friese-Greene's invention as were applied to the wholesale clothes trade, the jam trade and so on, decided that it could not be worked commercially. He hoped and believed a similar view might not obtain to-day.

He had been struck by the honesty of Mr. Claude Friese-Greene's statements. Just as Mr. Claude Friese-Greene's father had invented commercial cinematography, so the son had invented the practice of making strictly honest and accurate claims in colour cinematography. He did not exaggerate what his method would do, nor did he claim to be using three colours when he was only using two, yet his results were appreciably better than those arrived at by other commercial methods of colour cinematography. There was a process which gave better results than the author's under certain conditions, but it required a special projector and had other disadvantages, and was uncommercial.

Mr. F. R. Newens said Mr. Friese-Greene's pictures were a great deal better than any others he had seen which could be produced commercially. He had recently seen the American colour film, "The Wanderer of the Wasteland," but the colours there were nothing like so rich as the author's, and there was no attempt to get the range of colour the author had obtained. He congratulated Mr. Friese-Greene on his results.

MR. B. V. STORR said he had been surprised at the results obtained. Some of the colours were not so true as the author himself would like to see them, but one could not expect to get perfection with a two-colour process; even when the inventor stated that he had not reached perfection one could hope that still better results would be obtained later on. He wondered how far the results could be improved by an improvement in the quality of the panchromatic emulsion, making it still more sensitive to green.

There was one point on which he was not quite clear. After describing his present method, where he dispensed with the use of the blue-green filter, Mr. Friese-Greene entered into an explanation of the action of the filters, still using the term "blue-green filter," although the exposure was not made through a filter of this colour.

MR. FRIESE-GREENE said he described in the beginning of his paper that the second exposure was a combination of white light and a colour on the red side of the spectrum. He had mentioned that he proposed to refer to that in future as the blue picture for the sake of simplicity. In effect it was the blue picture, although the combination was white and red.

A MEMBER OF THE AUDIENCE said he had been struck by the stereoscopic effect obtained in some of the pictures, and would like to know whether it was accidental or deliberate, and whether it had any relation to the fact that the alternate picture through the red filter must have a pronounced mis-cut effect, while the picture through the blue-green filter would have the opposite effect.

MR. FRIESE-GREENE said he always tried to obtain a stereoscopic effect if possible when taking pictures. He thought that referred to was caused by the fact that the photograph showed an object close to the camera which was moving slightly against a background of duller hue which was slightly out of focus.

THE CHAIRMAN proposed a very hearty vote of thanks to the author for his lucid and interesting description of his process, and for the beautiful colour pictures he had shown.

The vote of thanks was carried unanimously.

THE LIBRARY.

The following books have been presented to the Library since the last announcement:—

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NOTES ON BOOKS.

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COMMERCIAL RELATIONS BETWEEN INDIA AND ENGLAND, 1601 TO 1757. By Bal Krishna. London: George Routledge and Sons, Ltd. 14s. net.

In this volume of 370+XXII pages, Dr. Bal Krishna, who is not only Professor of Economics, but also Principal of the Rajaram College, Kolhapur, gives us a masterly study of the greatest commercial event known in history, a study which will certainly add to the reputation of our author as economist, as historian and a skilled book-maker.

By the term skilled book-maker, we intend to include not only the power of writing concisely, accurately and pleasantly, much as Goldsmith wrote, but also the very various powers which conduce to the making of a thoroughly useful book, such as a sense of balance or proportion in selecting records and matter of the right sort from their original sources, compiling useful bibliographies, indexing, cross-referencing, and annotating.

Linschoten's map of Asia (1598), which forms the frontispiece, assists materially in understanding the first chapter and its bearings on the outlook. The Indian population, naturally abundant by reason of warm climate and good cultivation, has been subject to severe privation during rainless years with consequent famine; then whole families would come forward and offer themselves as slaves, in order to obtain subsistence. Hence, probably, the remarkable aspect of voluntary slavery (p. 41), a condition of which the Portuguese traders of the later Tudor period availed themselves to the utmost.

Details of this traffic as recorded by Linschoten or others have interest not only from the standpoint of the work under notice, but also from other points of view; and it seems that even cultured ladies from all parts of India were sold in the slave market of Goa, the Portuguese Settlement within the Bombay Presidency.

On p. 53 we read of the beginnings of the first Dutch and English combined trading scheme, but owing to the widespread influence of the Portuguese Java was made a headquarters.

This first joint-stock venture appears to have been financed in 1600, and its first decade of active work (1601-1611) showed quite remarkable profit by legitimate trading, with distinct signs of weakening the subversive influence of the Portuguese; while at the end of the second decade (1621) we find an account of a detailed report presented to Parliament by the now established Company, the substance of which is that legitimate trading having many indirect advantages for both nations also showed the ratio of money to goods sent out as only a little under two to one, pp. 56, 57 and 58.

In giving us his study of commerce between India and England, with its brilliant successes and occasional periods of no profit or reverse, Dr. Bal Krishna has emphasised those historical incidents which seem to cast light on the great social questions of the day, thus presenting us with a work of real value to every student of political economy and of interest to every general reader.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock:—

MAY 6.—AIR VICE-MARSHAL SIR WILLIAM SEFTON BRANCKER, K.C.B., A.F.C., Director of Civil Aviation, Air Ministry, "Commercial Aviation." HIS GRACE THE DUKE OF SUTHERLAND, President of the Air League of the British Empire, will preside.

MAY 13.—(Joint Meeting of the Royal Society of Arts, the Royal Aeronautical Society, and the Anglo-Batavian Society.) THOMASSEN À THUESSINK VAN DER HOOP, "The Flight to the Netherlands East Indies." (The paper will be read in English). MAJOR-GENERAL SIR FREDERICK SYKES, G.B.E., K.C.B., C.M.G., M.P., will preside.

MAY 20.—PROFESSOR JOHN AMBROSE FLEMING, M.A., D.Sc., F.R.S., "William Sturgeon and the Centenary of the Electro-magnet." ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council of the Society, will preside.

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

MAY 8.—SIR GILBERT T. WALKER, C.S.I., M.A., F.R.A.S., Sc.D., Ph.D., F.R.S., "Indian Meteorology." SIR REGINALD ARTHUR MANT, K.C.I.E., C.S.I., will preside.

MAY 22.—SIR ALFRED CHATTERTON, C.I.E., B.Sc., Assoc.M.Inst.C.E., "The Industrial Progress of the Mysore State."

JUNE 12.—BRIGADIER-GENERAL SIR PERCY M. SYKES, K.C.I.E., C.B., C.M.G., "The Heart of Asia and the Roof of the World."

DOMINIONS AND COLONIES SECTION.

Thursday afternoon, at 4.30 o'clock :—

JUNE 18.—HON. W. G. A. ORMSBY-GORE, M.P., Under Secretary of State for the Colonies, "East Africa."

HOWARD LECTURE.

Monday evening, at 8 o'clock :—

PROFESSOR JOHN SAMUEL STRAFFORD BRAME, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, "Motor Fuels."

SYLLABUS.

LECTURE III.—MAY 4TH.

The combustion of motor fuels. Compression and efficiency. Pre-ignition and detonation. Researches of Ricardo and Midgley and Boyd. Anti-detonation efficiency of fuel components. Special "anti-detonating" agents—"ethyl gas." Mixture fuels. Problems of production. Practical results.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, MAY 4..Royal Institution, Albemarle Street, W. 5 p.m. General Meeting.

Farmers' Club, at the Surveyors' Institution, 12, Great George Street, S.W. 4 p.m. Madame Agresti, "The International Institute of Agriculture as an Aid to Farmers."

Surveyors' Institution, 12, Great George Street, S.W. 8 p.m. Major H. Barnes, "New Methods of House Construction."

Chemical Industry, Society of, at the Chemical Society, Burlington House, Piccadilly, W. 8.15 p.m. Mr. J. E. Hackford, "Gas Production from Heavy Oils by Partial Combustion."

Victoria Institute, Central Buildings, Westminster, S.W. 4.30 p.m. Paper by Prof. E. Naville, of Geneva.

Engineers, Society of, at the Geological Society, Burlington House, Piccadilly, W. 5.30 p.m. Mr. R. C. S. Walters, "Water Power Exhibits at the British Empire Exhibition, Wembley, 1924."

Transport, Institute of, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C. 5.30 p.m. Mr. F. Ayton, "Electrically Propelled Vehicles for Road Transport."

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. A. V. Hill, "Biochemistry." (Lecture I.)

At King's College, Strand, W.C. 5.15 p.m. Mr. E. Bevan, "Greek Views of the Beginning and End of the World."

5.30 p.m. Prof. R. Dyboski, "The New Poland."

5.30 p.m. Rev. Canon Burnett H. Streeter, "Primitive Church Order." (Lecture I.)

At the London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. Mr. P. J. N. Baker, "The Reconstruction of Hungary."

5 p.m. Prof. A. Van Gennep, "Some New Methods in the Study of Primitive Man." (Lecture I.). Lectures II. and III. on May 7 and May 8.

TUESDAY, MAY 5..Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 5.30 p.m. Mr. F. G. Rappoport. "Some Notes on Water Shut Off."

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. (James Forrest Lecture.) Capt H. R. Sankey, "Heavy-Oil Engines: Some Outstanding Questions Relating to Large Engines of the Self-Ignition Type."

Royal Institution, Albemarle Street, W. 5.15 p.m Prof. J. Barcroft, "Effects of Climate on the Circulation." (Lecture III.) "Wind."

Alpine Club, 23, Savile Row, W. 8.30 p.m. Dr. N. S. Finzi, "Some Climbs in the Bregaglia and the Dolomites."

Anthropological Institute, 52, Upper Bedford Place, W.C. 8.15 p.m.

Photographic Society, 35, Russell Square, W.C. 7 p.m.

Physiology, London College of, 8, Taviton Street, W.C 8.15 p.m. Mr. C. J. Tabor, "The Evolution of Marriage."

University of London, at the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Dr. D. Subotic, "Serbian Traditional Folk Poetry in English Literature, from Sir Walter Scott to the Present Day." (Lecture II.)

WEDNESDAY, MAY 6 .. Geological Society, Burlington House, Piccadilly, W. 5.30 p.m. Mr. E. B. Bailey, "The Tertiary Igneous Geology of the Island of Mull."

Metals, Institute of, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W. 8 p.m. Prof. Dr. H. A. Lorentz, "The Motion of Electricity in Metals."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. (Wireless Section.) Capt. H. J. Round, Messrs. T. L. Eckersley, K. Tremellen and F. C. Lunnon, "Report on Measurements Made on Signal Strength at Great Distances During 1922 and 1923 by an Expedition sent to Australia."

Public Analysts, Society of, Burlington House, Piccadilly, W. 8 p.m. (1) Mr. J. King, "The Adulteration of Conserves, with Special Reference to Pectin and Agar-agar." (2) Messrs. J. S. Willcox and H. T. Cranfield, "The Influence of Palm Kernel Meal on the Composition of Bacon Fat." (3) Messrs. C. H. Ridsdale and N. D. Ridsdale, "Points Arising from the Analytical Standardisation of British Chemical Standards." (4) Dr. B. S. Evans, (a) "A New Method for the Separation and Determination of Tin in Alloys," and (b) "A New Colorimetric Method for the Determination of Cobalt in the Presence of Nickel." (5) Mr. W. B. Walker, "The Determination of Small Amounts of Iron by Colorimetric Methods."

University of London, King's College, Strand, W.C. 5.30 p.m. Mr. H. W. Steed, "The Quintessence of the Eastern Question in its relation to Central Europe. (The Partition of Poland.)"
At the London School of Economics, Houghton Street, Aldwych, W.C. 5 p.m. Prof. Sir Francis Du Pre Oldfield, "Indian Codification: Its Merits and Demerits."

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. (1) Joint Meeting with Engineering and other Institutions to consider the work of the Special Committee on Tabulating the Results of Heat-Engine Trials. (2) Mr. J. Carnaghan, "A Standard Code for Tabulating the Results of a Heavy-Oil Engine Trial."

THURSDAY, MAY 7.. Royal Society, Burlington House, Piccadilly, W. 4 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p.m.

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. H. J. Fleure, "Prehistoric Trade and Traders of the West Coast of Europe." (Lecture I.)

Chemical Society, Burlington House, Piccadilly, W. 8 p.m. (1) Mr. E. H. Ingold, "The Tautomerism of Dyads. Part III. The Effect of the Triple Linking on the Reactivity of Neighbouring Atoms." (2) Messrs. J. O. Cutter, H. Burgess, and T. M. Lowry, "The Rotatory Dispersive Power of Organic Compounds. Part XVI. Halogen-Derivatives of Camphor." (3) Messrs. S. Sugden, J. B. Read and H. Wilkins, "The Parachor and Chemical Constitution. Part I. Polar and Non-Polar Valencies in unsaturated Compounds." (4) Messrs. J. P. Griffiths and C. K. Ingold, "The Tautomerism of Dyads. Part IV. New Evidence of the Tautomeric Mobility of Oximes."

Linnean Society, Burlington House, Piccadilly, W. 5 p.m. (1) Mr. G. C. Robson, "Exhibition of the Rare Cephalopod Spirula." (2) Sir S. F. Harmer, "Specimens illustrating Old Age in Cetacea." (3) Dr. H. G. Cannon, "Specimens Showing Ectodermal Origin of Muscles in the Crustacean Cheirocephalus." (4) Miss Anderson, "The Genetics of Ferns." (5) Mr. S. L. Moore, "A Third Contribution to the Composite Flora of Africa."

Iron and Steel Institute, at the Institution of Civil Engineers, Great George Street, S.W. 10 a.m. Annual Meeting. (1) Presidential Address. (2) T. W. Hand, "Progress in British Rolling-mill Practice." (3) A. Hultgren, "'Flakes' or 'Hair Cracks' in Chromium Steel, with a Discussion on 'Shattered Zones' and 'Transverse Fissures' in Rails."
2.30 p.m. (1) Messrs. T. H. Turner and J. D. Jevons, "The Detection of Strain in Mild Steels." (2) Mr. J. D. Jevons, "Strain Detection in Mild Steel by Special Etching." (3) Messrs. L. Aitchison and L. W. Johnson, "The Effect of Grain upon the Fatigue Strength of Steels." (4) Messrs. A. G. Lobley and C. L. Betts, "The Influence of Gases at High Temperatures upon Iron, with special reference to the Formation of Blowholes."

Fison Memorial Lecture, at Guy's Hospital Medical School, S.E. 5 p.m. Sir J. J. Thomson, "The Structure of Light."

Mechanical Engineers, Institution of, (N.-Western Branch), in the Engineers' Club, Albert Square, Manchester. 7 p.m. Fourth Report of the Steam Nozzles Research Committee.

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. P. Geyl, "The Dutch in the East Indies." (Lecture II.)
5.15 p.m. Prof. J. E. G. de Montmorency, "African Customary Law." (Lecture I.)
At King's College, Strand, W.C. 5.30 p.m. Prof. A. Cabrera, "Prehistoric Paintings in Spain."
6.30 p.m. Dr. O. Vocadlo, "The Czechoslovak Republic To-day." (Lecture III.)

FRIDAY, MAY 8.. Iron and Steel Institute, at the Institution of Civil Engineers, Great George Street, S.W. 10 a.m. Annual Meeting continued. (1) Messrs. R. H. Greaves and J. A. Jones, "Temper-brittleness of Steel: Susceptibility to Temper-brittleness in Relation to Chemical Composition." (2) Messrs. D. H. Ingall and H. Field, "'Peeling' in White Heart Malleable." (3) Messrs. R. L. Smith and G. E. Sandland, "Some Notes on the Use of a Diamond Pyramid for Hardness Testing." (4) Mr. J. H. Whiteley, "Observations on Martensite and Troostite." (5) Mr. B. D. Enlund, "On the Structure of Quenched Carbon Steels."

Royal Institution, Albemarle Street, W. 9 p.m. Dr. H. H. Dale, "The Circulation of Blood in the Capillary Vessels."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 6 p.m. Fourth Report of the Steam-Nozzles Research Committee.

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. A. C. Wire, "Five Weeks in the High Alps."

Engineers, Junior Institution of, 39, Victoria Street, S.W. 7.30 p.m.

Astronomical Society, Burlington House, Piccadilly, W. 5 p.m.

Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W. 6 p.m.

Aeronautical Engineers, Institution of, at the Engineers' Club, Coventry Street, W. 6.30 p.m. Capt. W. H. Sayers, "A Résumé of Achievements in Aviation during the Past Year."

University of London, King's College, Strand, W.C. 5 p.m. Dr. A. W. Rogers, "The Physical Features of South Africa in Relation to its Geological Structure and History." (Lecture II.)
5.30 p.m. Prof. F. J. Cole, "The History of Protozoology." (Lecture II.)

Central Asian Society, at the Royal United Service Institution, Whitehall, S.W. 5 p.m. Air Vice-Marshal Sir William Sefton Brancker, "Air Routes in Asia."

SATURDAY, MAY 9.. Royal Institution, Albemarle Street, W. 3 p.m. Mr. G. L. Bickersteth, "Byron and Italian Literature."

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FRIDAY, MAY 8, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

WEDNESDAY, MAY 13th, at 8 p.m. (Joint Meeting of the Royal Society of Arts, the Royal Aeronautical Society, and the Anglo-Batavian Society.) THOMASSEN À THUESSINK VAN DER HOOP, "The Non-Stop Flight to the Netherlands East Indies." (The paper will be read in English.) MAJOR-GENERAL SIR FREDERICK SYKES, G.B.E., K.C.B., C.M.G., M.P., will preside.

COUNCIL.

A meeting of the Council was held on MONDAY, APRIL 20th. Present:—Lord Askwith, K.C.B., K.C., D.C.L., in the Chair; Sir Charles H. Armstrong; Captain Sir Acton Blake, K.C.M.G., K.C.V.O.; Sir Archibald Denny, Bt., LL.D.; Mr. P. M. Evans, M.A., LL.D.; Sir Herbert Jackson, K.B.E., F.R.S.; Major Sir Humphrey Leggett, D.S.O., R.E.; Sir Philip Magnus, Bt.; Sir George Sutton, Bt.; Mr. Alan A. Campbell Swinton, F.R.S.; Sir Frank Warner, K.B.E., and Sir Philip Watts, K.C.B., LL.D., F.R.S., with Mr. G. K. Menzies, M.A. (Secretary of the Society) and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

A resolution of sympathy with the Marchioness Curzon of Kedleston was passed on the death of Lord Curzon, a Vice-President of the Society.

The number of entries for the April Examinations was reported—27,568, as compared with 27,273 in 1924, an increase of 295.

Arrangements for the Trueman Wood Lecture in the session of 1925-26 were considered.

The question of the award of the Albert Medal for 1925 was further considered.

The conditions of the Fothergill Prize were settled (see below).

Other formal business was transacted.

FOTHERGILL PRIZE.

Under the Fothergill Trust the Council of the Royal Society of Arts offer a Prize of £100 for an essay on "Fire Waste (Loss of Property by Fire) and its Effects on the Economics of National Life in Great Britain."

Intending Competitors must send in their essays not later than July 31st, 1926, to the Secretary, Royal Society of Arts.

The essays must be typed or clearly written. They may be sent in under the author's name, or under a motto, accompanied by a sealed envelope enclosing the name, as preferred.

The Judges will be appointed by the Council.

The Council reserve the right of withholding the Prize or of awarding a smaller Prize or Prizes, if in the opinion of the Judges no suitable essay is submitted.

The Council also reserve an option on the copyright of the successful essay.

G. K. MENZIES,
Secretary.

NINETEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 29th, 1925. SIR GEORGE NEWMAN, K.C.B., M.D., D.C.L., F.R.C.P., Chief Medical Officer, Ministry of Health, in the Chair.

The following candidates were proposed for election as Fellows of the Society :

Fry, Ambrose, Liverpool.
Horstsmann, E. H., Bath.
Jain, B. Trilok Chand, Meerut, India.
Lewis, Walter Basil, Liverpool.
Robertson, R., Beckenham, Kent.
Stock, Peter, J.P., Southport, Lancs.
Wallis-Whiddett, Frederic George, London.

The following candidates were duly elected Fellows of the Society :—

Friese-Greene, Claude Harrison, London.
Logan, Alexander, Calcutta, India.
Lumsden, George James, Freuchie, Fife.

A paper on "The Trend of Modern Hygiene" was read by DR. ANDREW BALFOUR, C.B., C.M.G., M.D., (Edin.).

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

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SEVENTEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 1ST, 1925.

MR. BYRON BRENAN, C.M.G., in the Chair.

THE CHAIRMAN, in introducing the lecturer, said the country about which the audience were going to hear something that evening was one which did not frequently come up in conversation or appear in the public Press, and he dared say that many of those present would have to take down their atlases in order to be quite sure where it was. Certainly, the Quarterly Index of *The Times* did not give it very much space. However, that was not altogether a misfortune, because if there was any truth in the saying that " Happy is the country without a history" the region which was not always on people's tongues was certainly very fortunate. There was, for example, in the valley of the Ruhr, a great deal more loose gunpowder dotted about than there was in the peaceful valley of Menam ; and the Isthmus of Kra sounded rather more peaceful than the Danzig corridor, where little rival States were always quarrelling as to who should have the management of the pillar boxes in the street. In spite of what he had just said, however, it must not be imagined that Siam was entirely a somnolent country and always in a state of torpor, as he thought the audience would agree after they had heard the lecture of Mr. Nunn, who had lived for a great many years in that country in an official position, and who was, therefore, very well qualified to speak on the subject.

The paper read was :—

SIAM: ITS PROGRESS AND POSSIBILITIES.

BY W. NUNN,

late Adviser to the Siamese Government on Customs and Excise.

Siam is a country of 200,148 square miles in area—about the size of Spain. Its greatest length is 1,020 miles and its greatest breadth 480 miles. It is bordered on the north by the British Shan States and the French Lao States ; on the south by the Gulf of Siam and the Federated Malay States ; on the west by Burma and the Indian Ocean ; and on the east by Indo-China. It is mountainous in the north, west, and south-west—a backbone of high land, with peaks rising to 7,000 and 8,000 feet, running from north to south on the western side. The south-eastern part of the country has some peaks of 5,000 to 6,000 feet. The great central district, through which runs the Menam Chao Phya—the one great river of Siam—is a huge alluvial plain, extending southward as far as the sea. (The word "Menam," which is usually given in the atlases as the name of the river, means merely "river.")

This great central plain, together with smaller plains, hill-enclosed in the mountainous North and in the peninsular regions, is the rice-producing country. The bulk of the rest of the country is jungle (forest) land, particularly in the north and all along the western border.

The population amounts to 9,513,000, of whom 800,000 are foreigners. The white races number 1,822.

The historical records of Siam are meagre until we come to comparatively recent times; but it is generally accepted that the Thai (Siamese) people originated in China, whence they were driven south to find acceptable asylum in the country now known as Siam or Muang Thai. The Thai tongue is still recognisable in the language of the people of Yunnan and Canton, and extends widely over Indo-China. Siamese historical records of the early days of their nation are inextricably involved with mythological stories, which, although extremely interesting to persons of poetic fancy, have little value as historical data. It is known that their power extended widely over the Indo-Chinese area, that it embraced Burma as far south as Tavoy, and that their influence was felt right down the Malay Peninsula and even to Java. Chinese records show that as late as the fourteenth century China claimed to exercise a suzerainty—apparently purely nominal as far as domestic affairs were concerned—over Siam; and Siam rendered tribute. There are very early records of Chino-Siamese trade, and of an extensive transit traffic between China and the Indian Ocean—Ceylon and the Persian Gulf—across what is now known as the Isthmus of Kra.

In the early sixteenth century came the first of the European adventurers to Siam. There are many interesting figures which emerge from the obscurity of that veiled period. The great Portuguese adventurer d'Albuquerque touched the lower portion of the Peninsula and sent his emissaries to Siam's capital. Davis, of Arctic fame, met his death in 1605 at the hands of Japanese pirates off the shores of the country. Ralph Fitch penetrated into upper Siam from Pegu, making his way through the great jungles on the borders—a wild forested region upon which the airmen Ross Smith and his brother looked down with dread when, on their famous flight from England to Australia, they lost their way. I remember Ross Smith telling me that they had begun to think seriously of the possibility of having to tree themselves on the thickest possible clump. Will Adams, the first Englishman to live in Japan, is recorded to have made voyages from Japan to Siam. The great buccaneer, Captain Kidd, started on his career of crime when he was commissioned to suppress piracy off the western coasts of Siam—the profits of piracy having tempted him from the less remunerative path of duty.

Portuguese, Dutch and English were successively concerned in opening up the country to knowledge of Western peoples and Western trade. The Portuguese lost their hold very soon, and their connexion with Siam is now traceable mainly in the names and lineaments of their descendants. The Dutch maintained their position for a considerable period, the English dropping out of competition for a time, but European commerce fell off until the early nineteenth century, when a new beginning was made of a traffic which has continued to grow in steadily increasing strength.

The domestic history of Siam, up to the early years of the nineteenth century, is largely a record of warfare against the Burmese, in which sometimes the Burmese, and sometimes the Siamese, were victorious; and, as always happens in such circumstances, the government of the country languished, the crown was held precariously, and the common people lived in a condition of slavery. Foreign trade was a royal monopoly, and the corruption, ignorance, and greed of the officials were an active discouragement of foreign commercial intercourse.

A new era dawned with the accession to the throne of King Mongkut, the priest king, grandfather of the present reigning monarch. His work of statesmanship was continued by his son King Chulalongkorn, whose death in 1910 was deeply and genuinely mourned throughout the country, and whose memory is still kept green by an annual ceremony in which the people take part spontaneously. Oriental ceremonies are frequently lacking in solemnity and impressiveness, but I do not remember any ceremony which so fully and so genuinely betokened a nation's grief as the cremation of King Chulalongkorn. The people felt that they had indeed lost the father of their country—the one man who, in changing times, could keep a strong hand upon personalities and influences which were already beginning to show undesirable symptoms.

The present King, King Rama VI (formerly known as King Vajiravudh), has had advantages of acquiring knowledge of Western ideas which were not available to his father and grandfather. He was educated at Oxford and Sandhurst, and for some time held a commission in the Durham Light Infantry. And he made good use of his opportunities. He is a well-read man in every sense of that term ; he has a real literary gift, and his knowledge of the various forms of art—and particularly that of the stage—is much more than that of the ordinary amateur. Since his advent to the throne the country's abandonment of the old Oriental methods of governmental administration has been quickened up very considerably. But more remarkable has been the change in the people themselves—in their ideas and their habits. That all of these changes are not entirely for good is not to be wondered at. Adolescence is an awkward period, and is often unlovely in some respects. On the whole Siam is going through the period well. There are no serious political troubles, and what is more to the point, there is no body of opinion with sufficient weight and strength to cause such troubles. Such public criticism of the administraion as one hears is usually of a very schoolboyish nature, and it is contrary to the character of the Siamese that they should take political agitation seriously. Siam is the most peaceful corner of the world. During the War hardly a ripple of a backwash of the great turmoil reached its shores.

The King of Siam is an absolute monarch. That does not mean that he is a tyrant. His word is final, but I doubt if any land is so free as Siam. One lives there year after year and almost forgets that there is a government—although, being human, one does not forget to grumble now and then. Think what it means never to have to fill up an Income Tax schedule; never to have to struggle with municipal rate assessors, never to be pestered by collectors of this or that! Even the Department with which I was concerned—the Customs and Excise—performed its functions so delicately and tactfully that its victims hardly knew how and when their money was extracted from their pockets. The taxation amounts to about seventeen shillings per head of the population.

The revenue is raised by land taxes, the sale of Government opium, Customs and Excise, Transit and Inland Tax duties, a light capitation tax, and certain fees. Opium is a Government monopoly. The drug is very strictly controlled, and the Government is carrying out a reasonable and steady policy of restriction.

The administration is conducted through ministers of state—Foreign Affairs, Finance, Interior, Commerce, Justice, Agriculture, Ways and Communications, and Education. These ministers are directly responsible to the King and must obtain the Royal sanction to everything which is not of a purely routine nature. There is a great council of ministers, which approximates to a cabinet, but in practice each minister deals with his own affairs—subject to the King's approval—and the council meets only to consider matters of abnormal importance.

The Government employs a number of foreign officials, some as advisers to the ministries and departments, and some as subordinate officers, to deal with work for which special qualifications are necessary; but the number of such officials is being steadily reduced, and trained Siamese are taking their places. The foreign officials come from many nationalities. There are British, French, Italian, Danish, American, and Belgians among them. The British predominate.

The European living in an oriental country is very apt to assume an attitude of superiority, and to take it for granted that the Government is incompetent, that things are done which ought not to be done, that things are left undone which ought to be done, and that there is no health in it. But it is necessary to preserve one's sense of proportion in these matters, and to consider not only the present conditions but the state of affairs which existed within living memory. Also it is not inadvisable to remind oneself that not all governmental incompetence is centred in the Orient, and that corruption and nepotism are not found exclusively in countries like Siam. Broadly speaking, Siam fifty years ago was a land of primitive conditions. To-day, it is a pleasant land with a well ordered system of government, with reasonably organised public offices, with a capital well built and having a fine road system, with an efficiently maintained railway system and road communications spreading steadily throughout the country, and with a people actively desirous of assimilating foreign ideas. In some respects, indeed, one sometimes wonders whether less rapid progression would not be better for the people.

Financial affairs are, on the whole, under reasonable control, and although in recent years the work of the ministry has been somewhat difficult, the position of the country financially is sound. The public debt amounts to £9,909,860. (My figures are for the year 1922-23.) The revenue in the same period was £7,690,000 and the expenditure £7,903,000. These are about double the figures of twenty years back. A deficit in the national budget has been a very unusual occurrence.

In the administration of justice, great strides have been made in the last two decades. With the aid of a number of European advisers, and by sending students abroad, a bench and bar are being built up which are establishing sound traditions. The Press and public opinion are playing their part in keeping the young administration clean-handed, and there is every reason to hope that it will mature creditably. The laws are being coded, a work which, chiefly in the hands of French lawyers, has not been pushed on with feverish haste, and which one might reasonably wish should be completed soon. Within a short period it is certain that extra-territorial jurisdiction will be no more. Great Britain abandoned it in the year 1909, Denmark followed within a few years, and the other foreign powers are following their example. Certain necessary safeguards have been and will be retained, but even without these there is no reason to fear that Siam will fail to strive to attain the ideal of justice at which it aims.

The advance in education has been noteworthy. A primary course is compulsory for boys and girls from the age of seven to fourteen. Boys who do not intend to proceed to a higher course are required to take an additional vocational course of two years. A secondary course is provided, the leaving standard being equivalent to the matriculation examination of a good university. There is a university in Bangkok, and two schools which are run more or less on the lines of British public schools. There is a similar school in the North. There are also various special schools, such as the Military, Naval, and Gendarmerie Colleges, the Law School, and the Posts and Telegraphs School.

The schools are based mainly on the British system, and English elementary and secondary masters are employed to assist the Siamese teachers, who have been mostly trained in England.

For many years it has been the practice to send scholars abroad, mostly to England, for further training at the expense of the Government, and it is quite usual for the higher class Siamese to send their boys, and frequently their girls, when quite young to schools in Europe. While the schools in Siam are good up to a point, and secondary education often reaches quite a remarkably high standard of efficiency, much remains to be done in the way of education. There is a tendency to copy the less desirable features of the elementary school system of England, and to ignore the real business of encouraging mental development. And too much importance should not be attached to the statement that Bangkok possesses a University. It is only in its infancy and it will be many years before it can be a University in anything more than name.

Excellent educational work is done by the French Roman Catholic missions, whose connexion with Siam dates from 1662; the American missionaries maintain some good schools.

Ways and Communications play a great part in modern Siam. Postal, telegraph, and telephone services are general, use being made of the Military Air Service for carrying mails to places otherwise difficult of access. But the railways are the most noteworthy addition to the evidence of progressive development. There are 2,379 kilometres of line open to traffic. Communication between Bangkok and the Northern Capital, Chiengmai, and southward between Bangkok and Penang is now possible by excellent day and night services; and there is under construction a bridge over the river at Bangkok which will within two years make it possible to run through trains from Penang to Chiengmai. The bulk of the foreign engineers employed in the railway service are British. A British engineer was in charge of the construction of the southern line, while a German staff had the work of the northern line in hand until 1917, when the entry of Siam into the War relieved them of their responsibilities. Both the Rail and Road Communications Services are in charge of a brother of the King, Prince Kambeng Bejra, who was at one time an officer in the British Royal Engineers.

Public health services have been given considerable attention of late years and have made good progress, in spite of a tendency—not so clearly observable in other directions—to attempt to achieve success on paper rather than in the field of practical service.

The Siamese people are essentially happy-natured. They are not deep; they are not generally subtle, though they may be on occasion artful. They are kindly and hospitable and very seldom other than courteous. Even in the lower orders of society one rarely finds uncouthness of deportment. Occasionally an official who is overwhelmed by the majesty of his office may try to be overbearing, but I believe that is observable in other countries too. They are proud, and disposed to think that Siam is the hub of the universe. Younger Siam may sometimes be arrogant and impatient; perhaps we should be the same if a large number of foreigners who came to our land showed a firm belief in their inborn superiority, simply because they are foreigners, combined with an equally strong desire to placate us for business reasons. But I think that the most striking trait of the Siamese of to-day is his calm acceptance of the conditions of modern civilisation. I do not mean merely that he is a ready student and assimilates Western knowledge and acquires Western ideas and manners easily. I know no Orientals who become, for instance, so thoroughly English in manner and deportment as the young Siamese who go through our public schools and universities—I mean that the Siamese seems to have no sense of amazement, no feeling of awed respect, aroused by the achievements of modern science. He has fallen heir to a ready-made civilisation, and he accepts it as simply as a child accepts the home to which he is born.

The Siamese is emphatically not a worker. He will drive a car or a train; he will serve as a train conductor, or a telephone linesman; but he will not undertake the ordinary forms of manual labour, except on his rice fields or under the compulsion of military discipline. He cultivates the whole of the rice of Siam, but the labour entailed is seasonal and not constant. Moreover, rice cultivation is a family affair. Practically all the rest of the manual labour of the country is done by Chinese. Carpenters, fitters, shoemakers, builders, painters, labourers, printers, mechanics—all are Chinese. An exception must be made in the case of the Northern Siamese, who are a sturdier type. The one discordant note in the otherwise perfectly harmonious ceremonial of the late King Chulalongkorn's cremation was the introduction of some fifty Chinese coolies to remove a staging.

Trading, wholesale and retail, is also dependent upon foreign enterprise and industry—mainly Chinese. Rice milling and rice buying are Chinese; the piece-goods market is in the hands of Chinese and Indians; and shipping is European or Chinese, but preponderatingly British. The teak concessions are held by Danish and British companies; the fishing industry is in the hands of Chinese. In no branch of commerce does the Siamese make headway—nor indeed does he make much effort to do so.

Generally speaking, the Siamese is born to clerical service; the Government offices are the goal of all Siamese students.

The Siamese soldier undergoes a rigorous training, and with proper equipment and staffing would probably give a good account of himself. Since conscription was introduced, in the present reign, the improvement in the physical condition of Siamese manhood has been most marked. As airmen they are expert and fearless, and the air force is a very earnestly directed and capably manned force.

As sailors the Siamese show little ability, although it must be admitted that when the Government took over some of the interned German ships during the War, Siamese officers and men navigated them between Bangkok and Hong Kong and Singapore with only one serious mishap. The ships did not run to schedule, however, and the undertaking proved far from profitable.

Siam is one of the strongholds of Buddhism, and although the modern tendency to be indifferent to religious matters is as observable in Siam as elsewhere, the people generally give as much attention to the practice of their faith as does the average resident in Christian countries in applying to his daily life the principles of his belief. With a large mass of ignorant peasantry it is inevitable that a great amount of superstition and belief in spirits and magic should be mixed up with religion, but I do not think the position is any worse in that respect to-day in Siam than it was in Europe one hundred years ago, shall we say? It must not be forgotten that modern Siam is very youthful, and if we find evidence of widespread belief in spirits amongst the common people it is not necessarily because they are an Oriental people, but because they have not had the opportunity of acquiring the knowledge that has freed us from the grip of superstition and made us so clear-minded, logical, and sane in dealing with matters which cannot be accounted for by the natural and scientific processes known to us. Doubtless, as the peasantry of Siam come more closely into touch with Western knowledge, there will be a new field opened up for the activities of the palmist, the crystal-gazer, the spiritualistic medium, and the advertising psycho-analyst. As it is, the Siamese attitude towards matters spiritual—their conception of their duty to God, their fellow-men, and themselves is simple. It is not complicated by the strife of sects, by the competition of conflicting faiths, by intellectual arrogance, nor by undisciplined enthusiasm. It is an attitude of unconcerned belief, quietly held and, if practised at all, quietly practised. If one of its most noticeable results is the congregating together of large bodies of idle priests, who toil not, neither do they spin, that result is not resented commonly by the people, nor does any form of priestly tyranny spring from it. The most striking characteristic of the religious life of Siam is its wonderful tolerance. Christian missionaries are as free to work in the country as if they were in a Christian land, and their educational and medical work is encouraged officially. It is interesting to note, as bearing upon this matter of religious toleration, that the weekly day of rest which is observed in the capital, in all Government offices, is the Christian sabbath, decreed to be an official holiday by King Chulalongkorn in the year 1899. It is to be hoped that nothing will ever happen in Siam to rob it of its being one country, at least, where the expression of religious belief does not disturb the peace and goodwill of men.

The climate of Siam has borne a bad reputation for many years—a reputation quite undeserved. I believe that early sailor visitors were responsible for that reputation, as they have so often been for other incorrect ideas about foreign parts. The sailor-man of the old days arrived at a port thirsty. He set a straight course for the nearest bar and a devious one back again, and that constituted the sum total of his knowledge of the place. The climate is much maligned. It is hot, of course. The temperature of Bangkok averages 87 degrees and during the S.W. monsoon there is much moisture and relaxing heat. And there are flying beasts in their season; and mosquitoes. But there is the glorious sunshine, the cool sweet air of the early mornings—almost always; the cool season—sometimes—when for several days the mid-day temperature may be down to 74 degrees or 76 degrees, and the night temperature in the bitter sixties. There is the ever fresh greenness of the trees, the lovely colouring of the young padi, the fine sky effects, the dry breeze of the hot season, the glorious feeling of freedom from the tyranny of clothes and heating apparatus, the always living in the open air; and always the sun, the friend if you do not fear him.

In the northern hill-land are the teak forests from which Siam derives one of its important products; but the timber from the other forest lands is very little worked, and many parts, especially along the Western border, are primeval jungle.

Some considerable quantity of redwood is worked in the Southern forests, as well as *Pradu* (Pterocarpus Spp.), *Yom Hom* (Cedrala Toona), *Phayoong* (Dalbergia Latifolia), *Yang* (Dipterocarpus Spp.), *Tabec* (Lagerstroemia Tomentosa and Lag. Calyculata).

In the peninsular country are found tin, wolfram, lead, and a certain amount of coal. Gold has also been found, although not in sufficient quantity to make its working a commercial possibility. From the same region come coconuts, rubber, wood-oil and damar.

The south-eastern district produces sapphires and small quantities of rubies; while gamboge, sticklac, gum benjamin, hides, horns, bones, and cardamoms are the produce of the country generally.

To the newcomer to the East there is a touch of romance about some of the exports of a country like Siam. Eagle-wood, sandal-wood and spices turn one's imagination back to the days of the merchant adventurers; and Customs statistics recall the enthralling pages of Hakluyt. The tiger-bone and rhinoceros-horn exports, eagerly sought by the Chinese for medicinal purposes, are hardly less interesting than a consignment of dried monkey paws, destined for the same end. One commodity to be found in the export list has an interest of more practical value; it is the *Krabau* seed (Hydnocarpus anthelminticus, Pierre), from which is extracted a remedy for leprosy which is giving most satisfactory results.

The total trade of Siam amounts to a value of £30,100,000, of which £13,600,000 represent the import trade, and £16,500,000 the export. The articles of import, in their order of importance, are textile goods, foodstuffs, metal manufactures, gunny bags, kerosine oil, tobacco, cigars and cigarettes, and machinery. The greatest volume of import trade is with Hong Kong. It would not be safe to set this to the credit of British trade, as a very great amount is transit traffic, and represents the activities of Japanese merchants. Next in order of value comes the United Kingdom, followed—at a considerable distance—by Singapore, China, India, Japan, the United States, Germany, Belgium, France and Holland.

Of the export trade, rice accounts for £13,000,000; tin for £1,700,000; and teak for £560,000. The places of consignment in their order of importance are: Hong Kong, leading with four-fifths of the total; Singapore with almost one-third; Netherlands India, a long way below; followed closely by China, the West Indies and Japan. The share of the United Kingdom, as revealed by statistics of commercial exchanges, amounts to only one-eightieth of the total.

Siam has made steady progress commercially. In the past twenty years it has more than doubled the volume of its trade. What does the future hold in store? Nothing of the nature of a boom, certainly, but, one believes, a continuance of the same steady progression. Much depends upon the Government. If influences adverse to good government are kept in check, if the administration continues to aim at improvement, and no obstructive forces are allowed to impede the freedom of commerce; and particularly, if impatience to achieve a sudden prosperity is restrained, there should be no fear that the position of the country will be steadily improved. It is in agriculture that the chief development may be expected to be made. Rice is now the chief crop and will continue to be, but coconuts, oil palms, oil nuts, kapok, jute and other fibre-producing plants are capable of great expansion.

The tin-bearing lands are by no means exhausted; thousands of square miles of densely timbered jungle remain untouched; and the fisheries have not yet been handled by modern methods.

For all these possible developments capital is required. That capital is not to be found in the country and must be introduced from outside. A great advance in the means of communication must also be made before many of these enterprises can become profitable; and most important of all, and particularly as far as the possibility of the extension of agricultural enterprise is concerned, some way must be discovered by which more plentiful, and cheaper, labour can be obtained.

Having opened up the country to commerce, having taken its stand as a commercial nation, Siam cannot afford to remain dependent upon the foreigner for commercial enterprise and skill, and for labour. Her hope for the future lies largely in the development of a commercial class, in inducing her young men to acquire practical knowledge of commercial methods and in the abandonment of her attitude of aloofness from commercial affairs. Mere stock-holding and indulgence in the excitement of share dealing will not establish her position in a world of business. Her young men must take their coats off and set to work under conditions more exacting than are found in Government offices, and learn in the hard school of experience how business is conducted.

DISCUSSION.

THE CHAIRMAN (Mr. Byron Brenan), in opening the discussion, said he thought that, after having heard the lecture and after having seen the admirable collection of views which the lecturer had exhibited, those present would all have come to the conclusion that Siam was a country which had a good many attractions, and that it was worthy of rather more study and notice than it had received hitherto by the Western hemisphere. It was pleasant to read of a people who were always cheerful, hospitable and polite and ready to be friendly. The stranger who went to Siam was sure to be met more than half-way in his intercourse with the friendly native, provided he was not too self-complacent and patronising as was rather too often the fault in the case of Western people going to Oriental countries. Having said so much on the credit side, one had to admit that there was a little to be said on the other side. It was to be gathered from the paper, and also from other sources of information, that the people of Siam were too much given to taking life easily and were averse from tackling any kind of a job which implied exertion. Thus it was that they quietly allowed alien intruders to come into their country and to take all the benefits and rewards of efforts which should really go to the sons of the soil. Except in the cultivation of the rice fields, which were the mainstay of the country, one had to look in all directions to find any kind of industry where the alien was not more than a match for the native on his own ground. The Siamese certainly cultivated their rice, but the rice mills were owned and managed by Chinese. The sugar mills were worked by Chinese, and the smaller industries like carpentering, ironwork, small shopkeeping, tailoring, and so on, were all run by Chinese. In Bangkok itself, with its large population, one-third of the inhabitants were Chinese. It was not the same as it was in other countries, notably the United States, and to a certain extent in England too, where the immigrant of to-day became the patriotic citizen of to-morrow; the Chinese who went to Siam went there, not on account of the salubrious climate, and not even to escape income tax, but to take the living out of the mouths of those who belonged to the country. They did not remain there, but, after making enough to satisfy their ambitions, they returned to the land of their fathers. At the beginning the

Chinese encountered a great many difficulties. They were strangers in the country, only partly welcome, and there was the great difficulty of the language. Siamese was a particularly difficult language, being built upon the roots of languages which had existed centuries ago, but which had now disappeared. As showing the difficulty of it, he might mention that it had 44 consonants and 32 vowels. It was only about 50 years ago that Siam made a serious effort to emerge from her backward civilisation, with its curious customs, cruelties and superstitions, and it had been owing to her last three kings that she had succeeded in qualifying herself to be put alongside civilised Western countries. The lecturer had shown how in Bangkok there was the framework of a Government edifice which was really the counterpart of what might be found in civilised European countries. Siam, therefore, was now extremely well-equipped to proceed on the road to success. In the earlier days of her history she had met with all the troubles and setbacks inseparable from racial quarrels and attacks from States on her borders, but that time had passed away. Those small States which had given trouble had been brought into subjection by Great Britain on the west and north-west and by the French on the east and north-east, so that Siam was now comfortably blanketed by the positions of those two great Powers. Not very long ago there had been a good deal of jealousy between England and France over the destiny of Siam, but that trouble had now been composed and an agreement had been signed guaranteeing the sovereignty and independence of Siam. Therefore, that country had nothing to interfere with her progress to continued prosperity.

MR. S. H. HENDRICK said he had very little to say except to confirm all that the lecturer had said with regard to the treatment which strangers received in Siam. He had been resident there for about 25 years, and he had been extremely sorry to leave the country. He had been very glad to notice the emphasis which Mr. Nunn had laid on the importance of the cultivation of rice in Siam. Rice formed about 90 to 95 per cent. of the exports of the country. There was a market right at her doors for practically the whole of the crop, as 85 to 90 per cent. of it went to China, the Straits and Java. If there was one thing which the Siamese did know it was how to grow rice, and of late years the Government of Siam had shown a very enlightened policy indeed in encouraging and extending irrigation. He believed there were several large schemes in contemplation which would be brought to fruition during the next few years. The Siamese did not need to go any further than rice in order to extend the trade of their country. Since he had been there the export of rice had increased from 700,000 tons to 1,300,000 tons, and there was ample land on which to grow twice the quantity, if only there was the population available. Unfortunately, Siamese rice had lost much of the good repute it once had, owing to anything having been shipped during the War. The seed had been very much mixed and not enough care had been taken in selecting it, with the result that the quality had suffered during the past ten years. Efforts were now being made to rectify that and to get Siamese rice back to its former good repute. If he might give a word of advice, it would be the following: all the Siamese Government had to do in order to increase the trade of their country was to concentrate on the irrigation schemes and on improving the quality and the milling of the rice exported from their country.

MR. R. à-ABABRELTON said he knew a great deal about South Africa and the Chinese population there, and he would like to ask the lecturer how it came about that the Chinese seemed to be doing so very well in Siam. In South Africa they did very badly, from various causes, which most people knew, and the authorities had to get rid of them. He would also like to say that it seemed to him that the Siamese climate was responsible for making very good speakers. All the speakers that evening—the Chairman, the lecturer and the last speaker—had spoken excellently.

MR. NUNN, in reply to Mr. à-Ababrelton, said the position of the Chinese in Siam was rather different from the position of the Chinese in South Africa. The South African Chinese were purely of the coolie class, who had been taken out there under a system of indentures, whereas the Chinese entered Siam of their own free will; they were not brought into the country, but they came in quite voluntarily, and they did to a certain extent stay there. If they themselves did not stay there their children certainly did, and in the children of the Chinese immigrants lay one of the great hopes of Siam, because those children retained a very great deal of the Chinese energy combined with a great deal of the finer qualities of the Siamese, and also something of the Siamese quickness of intelligence. The Chinese in Siam certainly did settle down as most excellent citizens, and their children also. He thought the reason why they went there was simply because there was work for them to do. There had been a long standing connexion between Siam and China, extending over many centuries. Centuries ago the Siamese shipping had been run by Chinese.

MR. R. à-ABABRELTON: Then the Chinese really rule the country?

THE LECTURER said they hardly did that, but they had carried the foreign commerce of the country centuries ago. The early foreign commerce of the country had been Chinese and Japanese. The records of commerce between China and Siam went back possibly to B.C. He thought the fact that China was so close to Siam possibly enabled the Chinese to feel more at home in Siam. There was also a great likeness between the climate of Siam and that of certain portions of Southern China. The conditions were the same; they were received well, and they found an opportunity for work. His experience of the Chinese was that wherever there was a chance of doing work and making profit out of it, there they would stop.

With regard to Mr. Hendrick's remarks, of course, Mr. Hendrick was an authority upon the subject of rice and there was no doubt that what he had said should be of very great value to the Siamese, although it was not new to them. They had been told it already. He believed that they had been told it by Mr. Hendrick while he was in Siam. There was no question that if the Siamese did put their backs into the matter of irrigating their land and producing more rice, and if they developed a commercial class, they would have an opportunity of building up a commerce which was not an entirely foreign commerce. At the present moment it was entirely foreign, and he wanted to see Siam take some part in it herself instead of devoting herself merely to the government of the country. She did the work of government with remarkable skill and ability, and there was no reason why, if her young men really took an interest in commerce—not merely a theoretical, but a practical interest—she should not develop on the practical side of commerce.

Before sitting down, he desired to make a few remarks with regard to the possibilities of Siam as a tourist centre. Now that the railway was so conveniently connected with Penang, it was a very simple matter for people who were making a trip round the world and going through Hong Kong to drop off at Penang and to go up to Siam—a matter of 33 hours—and to see something of an extremely interesting country. It would pay tourists to do that and to see something really of the East and its romance, rather than to go down to such an extraordinarily uninteresting and highly developed and civilised place as Singapore.

With regard to business, he would like to say that he felt that the British people had to keep their eyes open for the future of their trade interests in Siam. Perhaps he was wrong, but he did feel that the younger generation of business men in Siam were not keeping up the reputation and the position of British firms. He did feel they were not quite the thorough and conscientious men of business that their forerunners were. They knew how to get from their bungalows to the sports club and from there to the British Club and back again to their bungalows. That was rather exaggerated, of course, but he felt that that just about summarised their knowledge of the country. They were very good fellows to meet, and they played a most excellent game of cricket, tennis or golf, but they were hardly the type of persons in whose hands the business interests of this country were going to be entirely safe. That was not so with regard to certain other European races, and he felt that if this country's business interests in Siam were going to be kept up, our business young men would have to take more interest in their work and get out of their present somewhat happy-go-lucky methods which seemed to have got into them since the period of the War. There was a certain danger from American competition. A large number of young Siamese were now being sent to America for training and they came back with American ideas, and naturally, when they had anything to do later on with business affairs, their sympathies would be more American than British. American interests were gaining ground there. The American motor-car, for instance, very largely outnumbered the British, and there was no real reason why it should. In dredging machinery the Americans were beating us. Generally speaking, he felt that the British commercial interests in Siam were not quite so bright as they were a few years ago.

With regard to the country generally, the great danger which seemed to be facing Siam at the present moment was the tendency to indulge in extravagance, personal and public. It seemed to him that a greater restraint in expenditure, from the highest quarters downwards, was absolutely essential if the financial situation of Siam was to remain sound.

A vote of thanks to the author terminated the meeting.

NOTES ON BOOKS.

UNEMPLOYMENT RELIEF IN GREAT BRITAIN. A Study in State Socialism. By Felix Morley. London: George Routledge and Sons, Ltd. 6*s.* net.

We have before us No. 77 of the well-known series of monographs issued by the London School of Economics (p. I), but this book is printed in the United States (p. IV), and it appears to be issued under the auspices of an American Educational Trust (p. VII); so the reader may find it desirable to consider carefully the introductory matter (pp. I-XVIII) in order to grasp the outlook of the author.

Unemployment relief, as distinguished from relief under our Poor Laws, is the subject-matter of Mr. Morley's book; he, however, centres largely on what is often called "State operated insurance," that is a condition generally comparable to insurances in the old or voluntary aspects, but with a State force behind it making non-contribution penal or *quasi*-criminal, and at the same time denying to the insured persons such legal remedies for failure, delay or default as are the common right of those who effect insurance by voluntary contract.

The author has collected facts, details and speculations having reference to recent British experiments, but there seems to be a tendency towards neglect of the older proposals for compulsory and universal insurance, like that brought before the Society of Arts by the Rev. W. L. Blackley, in a communication read at the meeting on July 14th, 1880, and appearing in the *Journal* of July 23rd, 1880, pp. 739-746. Among the writings in which the broad question of the relative desirability of compulsory and voluntary insurance are set out in contrast or balance, we may mention the comprehensive study by Mr. Miles M. Dawson, this study forming the article "Insurance" in the 1879 edition of the Bliss Encyclopædia of Social Reform.

Perhaps in ten years' time economists will be able to form an opinion as to the merits or demerits of the two systems for sectional or partial insurance now on trial in Great Britain, but in relation to the more recent of the two, one prospective difficulty appears to rest in satisfactorily defining industries, a matter which Mr. Morley considers (p. 156). He suggests the desirability of retaining a Crown official as final arbiter in demarcation disputes.

Metallurgy: An Elementary Text Book. By E. L. Rhead. London: Longmans, Green and Co. 7*s*. 6*d*.

A new and revised edition of this first study in the Arts of Vulcan will be acceptable to the general reader who wishes to get fundamental notions in their latest aspects; for example, as regards electric furnaces there is a general classification, pp. 58-59, into induction furnaces in which the charge is a secondary conductor of an induction unit, and resistance furnaces in which the effective heat is produced in the main circuit. Industrial electric furnaces are for the most part resistance furnaces; the charge itself, embedded rods, the actual body of the furnace, or a wirework plexus being the imperfect conductor in which the heat is produced, and we are told that wire made from an alloy of nickel 4 and chromium 1 is safe up to a temperature of 1100° C. On p. 207 are notes as to the arc electric furnace, almost a type in itself, and on p. 24 are notes on electric welding devices.

The cult of the new is, however, not overdone, as on p. 207 is a sectional drawing of a good pattern of the old laboratory wind furnace, still useful for making special alloys and in purifying gold by the chlorine process.

Alloys are well studied in many aspects, and, as an example of good practical tabulation, we may refer to the conspectus as to brasses on p. 386.

MEETINGS OF THE SOCIETY.

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Ordinary Meetings.

Wednesday evenings, at 8 o'clock:—

May 13.—(Joint Meeting of the Royal Society of Arts, the Royal Aeronautical Society, and the Anglo-Batavian Society.) Thomassen à Thuessink van der Hoop, "The Flight to the Netherlands East Indies." (The paper will be read in English). Major-General Sir Frederick Sykes, G.B.E., K.C.B., C.M.G., M.P., will preside.

May 20.—Professor John Ambrose Fleming, M.A., D.Sc., F.R.S., "William Sturgeon and the Centenary of the Electro-magnet." Alan A. Campbell Swinton, F.R.S., late Chairman of the Council of the Society, will preside.

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

MAY 22.—SIR ALFRED CHATTERTON, C.I.E., B.Sc., Assoc.M.Inst.C.E., "The Industrial Progress of the Mysore State." SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S., will preside.

JUNE 12.—BRIGADIER-GENERAL SIR PERCY M. SYKES, K.C.I.E., C.B., C.M.G., "The Heart of Asia and the Roof of the World."

DOMINIONS AND COLONIES SECTION.

Thursday afternoon, at 4.30 o'clock:—

JUNE 18.—HON. W. G. A. ORMSBY-GORE, M.P., Under Secretary of State for the Colonies, "East Africa."

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, MAY 11..Geographical Society, 135, New Bond Street, W. 8.30 p.m. Mr. H. St. J. B. Philby "The Dead Sea to Agaba."

Philologie, Sciences et Beaux Arts, Société Internationale de, 8, Taviton Street, W.C. Dr. C. E. Ball, "Lafcadio Hearn."

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. J. Barcroft, "Effects of Climate on the Circulation." (Lecture IV.)

University of London, University College, Gower Street, W.C. 5 p.m. Prof. G. D. Hicks, "Hegel's Æsthetics." (Lecture I.)

5.30 p.m. Prof. A. V. Hill and Prof. J. C. Drummond, "Bio-Chemistry." (Lecture II.)

At King's College, Strand, W.C. 5.15 p.m. Prof. J. A. K. Thomson, "Agamemnon."

5.30 p.m. Dr. R. Dyboski, "The New Poland." (Lecture III.)

At the London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. Mr. P. J. N. Baker, "The Greek Refugee Settlement Loan."

At the London Day Training College, Southampton Row, W.C. 5.30 p.m. Dr. G. Dyson, "The Evolution of Instrumental Music." (Lecture I.)

At Gresham College, Basinghall Street, E.C. 6.15 p.m. Mr. A. Compton-Rickett, "Some Writers of Yesterday and To-day." (Lecture III.) "Henrik Ibsen."

TUESDAY, MAY 12..British Empire Shakespeare Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 3 p.m. Miss Esmé Beringer, "Lady Macbeth."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C. 8.30 p.m. Air Vice-Marshal Sir Sefton Brancker, "Imperial Air Routes to India and Australia."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Meeting of the Scientific and Technical Group.

Physiology, London College of, 8, Taviton Street, W.C. 8.15 p.m. Dr. H. R. Foote, "Rheumatism."

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Annual General Meeting.

University of London, at King's College, Strand, W.C. 5.30 p.m. Rev. Canon B. H. Streeter, "Primitive Church Order." (Lecture II.)

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Dr. D. Subotic, "Serbian Traditional Folk Poetry in English Literature, from Sir Walter Scott to the Present Day." (Lecture III.)

WEDNESDAY, MAY 13..Transport, Institute of, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C. 10 a.m. London Congress. 1. Colonel Sir John Pringle, "Ministry of Transport Requirements, 1925." 2. Comr. C. D. Burney, "Airships and Their Uses, both as Commercial Vessels and in Time of War."

British Academy, at King's College, Strand, W.C. 5.15 p.m. Annual Shakespeare Lecture by Mr. H. Granville-Barker, "From Henry V to Hamlet."

University of London, at King's College, Strand, W.C. 5.30 p.m. Mr. H. W. Steed, "Central Europe, Roumania and the Near East." (Lecture II.) "The Struggle for Mastery in Central Europe (1848-1870)."

At the London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. Mr. R. A. Smith, "The Metal Ages in Western Europe." (Lecture I.) "The Bronze Age (2000-500 B.C.)"

THURSDAY, MAY 14..Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. H. J. Fleure, "Prehistoric Trade and Traders of the West Coasts of Europe." (Lecture II.)

Transport, Institute of, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C. 10 a.m. Congress continued, Mr. D. R. Lamb, "The Co-ordination of Rail and Road Transport."

Historical Society, 22, Russell Square, W.C. 5 p.m. Miss M. H. Mills, "Experiments in Exchequer Procedure, 1200-1232."

Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p.m.

Mechanical Engineers, Institution of, (North-Western Branch), in the Engineers' Club, Albert Square, Manchester. 7.15 p.m. Annual Meeting. Mr. S. J. A. Panton, "Practical Locomotive Superheating."

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. P. Geyl, "The Dutch in the East Indies." (Lecture III.)

5.15 p.m. Prof. J. E. G. de Montmorency, "African Customary Law." (Lecture II.)

At King's College, Strand, W.C. 5.30 p.m. Prof. A. Cabrera, "Prehistoric Painting in Spain." (Lecture II.)

6.30 p.m. Dr. O Vocadlo, "The Czechoslovak Republic To-day." (Lecture IV.)

FRIDAY, MAY 15..Royal Institution, Albemarle Street, W. 9 p.m. Prof. C. G. Darwin, "Recent Developments in Magnetism."

Transport, Institute of, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C., 10 a.m. Congress continued. 1. Mr. A. E. Brookes, "Arterial Roads in Relation to Town Planning." 2. Mr. H. J. Deane, "Modern Dock Equipment."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Meeting of the Pictorial Group.

Philological Society, University College Gower Street, W.C. 8 p.m. Prof. E. Weekley, "Some New Etymologies."

University of London, at King's College, Strand, W.C. 5 p.m. Dr. A. W. Rogers, "Physical Features of South Africa in relation to its Geological Structure and History." (Lecture III.)

At St. Bartholomew's Hospital Medical College, West Smithfield, E.C. 5 p.m. Dr. H. H. Dale, "Chemical Control of Certain Bodily Functions." (Lecture I.)

Shakespeare Association, at King's College, Strand, W.C. 5.30 p.m. Mrs. C. C. Stopes, "Some Early Records illustrating the Personal Life of Shakespeare.

SATURDAY, MAY 16..Royal Institution, Albemarle Street, W. 3 p.m. Mr. G. L. Bickersteth, "Byron and Italian Literature." (Lecture II.)

A.J.S.

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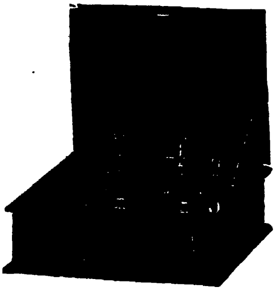

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JOURNAL OF THE ROYAL SOCIETY OF ARTS

No. 3782 VOL. LXXIII.

FRIDAY, MAY 15, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

WEDNESDAY, MAY 20th, at 8 p.m. (Ordinary Meeting.) PROFESSOR JOHN AMBROSE FLEMING, M.A., D.Sc., F.R.S., " William Sturgeon and the Centenary of the Electro-magnet." ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council of the Society, will preside.

FRIDAY, MAY 22nd, at 4.30 p.m. (Indian Section.) SIR ALFRED CHATTERTON, C.I.E., B.Sc., Assoc.M.Inst.C.E., " The Industrial Progress of the Mysore State." SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S., will preside. Tea and coffee will be served in the Library from 3.45 p.m.

FOTHERGILL PRIZE.

Under the Fothergill Trust the Council of the Royal Society of Arts offer a Prize of £100 for an essay on " Fire Waste (Loss of Property by Fire) and its Effects on the Economics of National Life in Great Britain."

Intending Competitors must send in their essays not later than July 31st, 1926, to the Secretary, Royal Society of Arts.

The essays must be typed or clearly written. They may be sent in under the author's name, or under a motto, accompanied by a sealed envelope enclosing the name, as preferred.

The Judges will be appointed by the Council.

The Council reserve the right of withholding the Prize or of awarding a smaller Prize or Prizes, if in the opinion of the Judges no suitable essay is submitted.

The Council also reserve an option on the copyright of the successful essay.

G. K. MENZIES,
Secretary.

TWENTIETH ORDINARY MEETING.

WEDNESDAY, MAY 6th, 1925. MR. ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council of the Society, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Langer, Carl, Ph.D., F.C.S., Woolhampton, Berks.
Lawford-Jones, Arthur John, Slough, Bucks.
Leonard, Ernest Arthur Edward, Barking, Essex.
McMurray, J., C.B.E., Teheran, Persia.
Mirchandani, Narain Khanchand, Sheffield.
Pehrson, A.P., Sheffield.
Radford, Henry C., Southampton.

The following candidates were duly elected Fellows of the Society:—

Dickson, Raynes Waite Stanley, Melbourne, Australia.
Dowling, Henry George, London.
Harding, Pearcy S., Sutton, Surrey.
Lieb, Dr. John William, New York City, U.S.A.
Lightfoot, Vernon Robert, Widnes, Lancs.
Manson-Bahr, Philip, D.S.O., M.D., F.R.C.P., London.
Norén, Herbert, Walvis Bay, South Africa.
Richards, Francis William, London.

A paper on "Commercial Aviation" was read by AIR VICE-MARSHAL SIR WILLIAM SEFTON BRANCKER, K.C.B., A.F.C., Director of Civil Aviation, Air Ministry.

The paper and discussion will be published in a subsequent number of the *Journal.*

INDIAN SECTION.

FRIDAY, 8th MAY, 1925. SIR REGINALD ARTHUR MANT, K.C.I.E., C.S.I., in the Chair.

A paper on "The Meteorology of India" was read by SIR GILBERT T. WALKER, C.S.I., M.A., F.R.A.S., Sc.D., Ph.D., F.R.S., Professor of Meteorology, Imperial College of Science and Technology, and late Director-General of Indian Observatories.

The paper and discussion will be published in a subsequent number of the *Journal.*

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "Modern Colour Problems," by Louis C. Martin, D.Sc., A.R.C.S., D.I.C., F.R.A.S., Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and Technology, have been reprinted from the *Journal,* and the pamphlet (price 2s.) can be obtained from the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures which have been published separately and are still on sale can also be obtained on application.

PROCEEDINGS OF THE SOCIETY.

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SIXTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 25th, 1925. MR. H. D. SEARLES-WOOD, F.R.I.B.A., in the Chair.

The paper read was :—

WALLPAPER: ITS HISTORY, PRODUCTION AND POSSIBILITIES.

By HENRY G. DOWLING.

INTRODUCTION.

The manufacture of wallpapers has become one of our most important art industries, and, viewed in relation to their wide use and consequent possibilities to influence public taste, should have the thoughtful consideration of all interested in artistic matters. I therefore make no apology for reading a paper dealing with the subject of wallpapers.

A BRIEF HISTORICAL OUTLINE.

The practice of ornamenting wall surfaces dates back to the earliest times. Almost daily we are receiving fresh evidences of the ancient Egyptian pictorial work, whilst the Pompeian remains attest that the mural painter's art was highly cultivated in Italy. But it is the tapestries, stamped leathers and woven stuffs which were used so extensively and for so long in Europe and among the Eastern countries that seem to have originated the earliest paper hangings, and there provided a less expensive method of finishing the walls of the homes where tapestries and woven stuffs could not be afforded.

To produce these imitations chopped wool, known as "flock," was employed, and the method as applied to paperhangings was originated, about 1620, by Le Francois, of Rouen, who continued in business for fifty years with great success. Jerome Lanyer, of London, saw the possibilities of the new process, and obtained a patent from Charles I., dated May 1st, 1634, for the exclusive right to manufacture flock hangings in England, giving them the name of Londrindiana. The record of the patent granted does not mention paper as one of the materials for the application of the flock, as it was not until late in the seventeenth century that paper was sufficiently serviceable for use as hangings.

The manufacture of flock papers was consistently improved and developed in England, and at a time when France had turned to other methods. They were exported to France and caused no little excitement amongst those who knew of the country's claim to its invention, and resisted the rage for the English papers. But during the period when we were perfecting flock printing, France had been making remarkable strides with block printing in colours, and improving the productions of the early Dominotiers, a group of men in France principally engaged in the making of marble papers, used then for the lining of boxes and books—papers closely resembling in manufacture and appearance the present-day ledger linings. In 1586 the Dominotiers combined with some wood engravers and produced by wooden blocks popular scenes, upholstery papers, and black and white checks for panels. These were all printed in black, afterward being finished in colours by brush with or without stencil. These Domino papers were pasted on the wall in sheets, and could be found in most houses of importance in France. As with to-day, trade jealousy was provoked and resulted in litigation, and enactments were made as to the type of work it was permissible for them to produce—the order even determining the type of press to be used, and that the work was to be executed in the presence of a master printer. In 1688 Jean Papillon, the Master Dominotier, set up the first great printing house for wallpapers. His thoroughness as a craftsman is indicated by the fact that he could, and actually did, carry out the complete process, making his own designs, putting them on to and carving the blocks, printing and colouring them, and even selling and hanging them. Papillon was the pioneer of continuous pattern in wallpapers, and naturally was soon imitated by competitors. Though in the "Treatise on Wood Engraving," his son Jean Michel refers to his father's papers as "illuminated," there is no record of Papillon printing from blocks in colours, yet it is evident that he was responsible for its accomplishment later by one of his chief apprentices, Jacques Chauvau, who perfected the process.

Round about this period Chinese paintings were being largely imported and were commanding high prices, and were also being laboriously copied by hand to supply the demand. The extraordinary development of European letterpress printing doubtless gave the incentive for producing these Chinese papers in colour and from separate blocks, and from then onwards block printing of wallpapers became a recognised industry in both countries. Often these Chinese paintings are referred to as "Indian," probably due to the fact that it was through the agency of the East India Company that these papers reached Europe.

Quite a few of these paintings can still be seen on the walls on which they were originally hung; one of the finest specimens being at Coutts' Bank, opposite Charing Cross Station—a present in 1792 from Lord Macartney, our first ambassador to China, to Mr. Coutts, the banker.

These particular paintings cover a space 20 x 30 by 12ft. high, and depict varied Chinese customs and industries.

So prevalent was the new vogue that a certain John Baptist Jackson, a maker of paper hangings at Battersea, commenced a reaction against it, and in 1754 published a curious self-laudatory book, written in the third person, on the invention of printing in chiaro-scuro and the application of it to the making of paper hangings "illustrated with prints in proper colours." His bombastic claims to have invented the process of block printing in colours seem characteristic of a man who, when he was employed in Paris by Papillon, was caught selling as his own one of his employer's creations. In his essay he denounced the glaring colours "which delight the eye that has no true judgment belonging to it," and offered in their place copies of the most celebrated classic subjects, statues and landscapes. He also proposed that, instead of painting paper hangings in the ordinary way with size colours, oil should be used, arguing the greater durability of it. Some of Jackson's prints are still in existence.

In France Reveillon had founded a wallpaper factory in Paris employing between three and four hundred workmen, the enterprise receiving King Louis XVI.'s warrant to the title "Royal Manufacturer." Reveillon had the accumen to enlist the services of well-known designers, amongst them being J. B. Huet (who created so many of the finest designs reproduced at Jouy by Oberkampf) and produced a very wide range of patterns. It was in his factory that the first outbreak of the French Revolution occurred, the mob destroying by fire his property, and Reveillon himself escaping to England. The development of paper hanging manufacture in France thereafter makes particularly interesting study. It would take too long this evening to tell of the many successors to Reveillon, but it was during the time of the Terror that the discovery was made of producing continuous paper without seams and divisions.

The house of Zuber, represented in this country by Mr. E. S. Theobald, was founded at Rixheim, near Mulhouse, in 1797, and is to-day producing undoubtedly the finest series of landscape papers, some of which involve many hundreds of blocks.

In 1830, printing by cylinder supplanted blocks, and, once the idea had been found workable, improvements came rapidly, and wallpaper printing seems to have started forward to the present highly-developed methods of production.

The first colour printing machine for wallpapers was exported to America in 1844 and to France in 1850. It was in the year 1839 that the firm of J. Potter, of Darwen, was established specially to carry on the manufacture of paper staining by machinery, and though its beginnings were of necessity tentative and limited in operation until the new process was finally demonstrated to be commercial in its character, from that time until the present, as a branch of the Wallpaper Manufacturers, Ltd., the firm have held a prominent position in the trade, with a reputation that extends over the civilised world.

If time permitted I would have liked to refer to the work carried on by the Echardts at Chelsea, and Mr. Sheringham (the Wedgwood of paper stainers) in Great Marlborough Street; but before giving an outline of the two chief methods of present-day production of wallpaper, would point out that during the period from 1779-1824 the importation of paper hangings into England was prohibited, and that until 1830 our paper stainers were restricted to printing in sheets, owing to the tax stamp on each sheet.

Some idea of the profits of the industry during that period can be gathered by comparing the annual amount of duty paid by paper stainers. In 1770 the revenue from the duty imposed amounted to £13,242 8s. 11d., which rose regularly, with one exception, to the sum of £63,795 16s. 9d. in the year 1834, and it must be remembered this duty was in addition to that of 3d. per lb. on plain paper, which tax was not abolished until 1861 by Gladstone.

THE MANUFACTURE OF WALLPAPER.

The principal methods of producing wallpapers are :—

(1) Hand printing from blocks.
(2) By machine.
(3) By stencil.
(4) By hand painting.

There is available for your inspection after the lecture an actual roller used in machine printing, also two blocks used in hand printing, but besides these I have had slides made showing some of the processes for each, and think these will be more or less self-explanatory.

Only a few factories are self-contained and actually manufacture their own raw material, though had I had the facilities and time, I could have shown by film all the processes of such a factory. In general appearance the printing machines closely resemble those used in textile mills, but their great difference is in the printing rollers. These rollers are made of maple or sycamore wood mounted on long iron spindles. From the original design prepared by the artist a series of tracings is made and put on to the rollers, one for each colour. Skilled craftsmen then proceed to cut lengths of brass ribbon and bend and cut them to form the outline of the particular colour shape. This brass projects about ¼ inch above the surface, and, where solid masses of colour are required, is filled in with specially prepared sodden felt, thus making a solid yet resilient printing surface after it has been ground evenly on a lathe. All the rollers required for the particular pattern are printed on the one printing machine, and by highly ingenious methods are geared up so that accurate registration is ensured. Each roller is supplied with the appropriate colour by means of a continuous felt sieve cloth, which picks up colour from the trough roller. Any excess of colour is dealt with by a blade or " doctor," which scrapes the cloth, allowing only sufficient colour to reach the printing roller. The paper is carried on a rubber blanket during actual printing to ensure perfect printing surface. Passing through the printer each roller contributes its colour share to the complete design, and as the printed paper emerges it is picked up by a series of automatically controlled wooden bars, which successively loops the paper, and which then proceeds through the drying chamber. Though theoretically the number of rollers is unlimited, usually twelve is the largest number employed, though I shew one with twenty colours. After travelling about ninety feet the wallpaper is thoroughly dry, and, unless it has to be overprinted or embossed, it is reeled and cut into rolls ready for the paperhanger.

Polished copper cylinders are used for printing "sanitary" papers, the design being traced or photographed on to the cylinder and then engraved by a series of stipple punches—really a coarser form of mezzotint engraving. By the use of the three primaries and a dark brown or black, manufacturers can produce every variety of colour and tone. The chief advantage of this process is that graduated tones and blends of colour can be obtained not possible with surface printing.

In hand printing you will notice that the block consists of three thicknesses of wood cemented together, the top, or cutting surface, being usually of sycamore or peartree wood. The outline is "rubbed down" on this fine surface and the design is coloured in with a wash of vermilion. The block in this state is handed to the block cutter, who goes over all the outline with tiny gouges and chisels, cutting the outline into the block to the depth of about 3/16ths of an inch. When the whole of the outline has been cut he removes all the superfluous surface of the block, leaving only those portions which were coloured by the tracer.

We have now a block with the design standing up in bold relief, but before it can be used to print a continuous design it must be provided with metal pins, which mark the top and bottom of the design. These are intended to print on the edge of the paper, which will be trimmed off by the paperhanger. These printed dots are used by the printer to register the repeat of the design. For the purpose of handling the block a short strap is nailed across the back, making a loop just large enough to allow the printer's hand to be inserted.

The printing table is still made on the pattern of those used in the earliest days of the craft. Pressure is brought to bear on the block by a "dolly pole" suspended over the centre of the table. This pole can be brought down by a simple system of levers worked by the foot of the printer. On the table is laid several thicknesses of felt, and over this is drawn the paper to be printed.

Beside the table stands the colour box. This consists of a box holding a few inches in depth of thick gum, upon which floats a shallow tray measuring about 36in. x 32in., the bottom of which is made of waterproof canvas, and on this is laid a square of felt. A lad or girl stands by the colour box to keep the square of felt well brushed over with the size colour used for printing. The printing block is dabbed on this colour, then laid on the paper to be printed, and the needed pressure is applied by the "dolly pole." The block then is returned to the colour case and the printed portion of the paper is drawn forward, leaving the next space in position ready for the next impression of the block. The printer follows on the work by fitting the leading pin or gauge on to the one at the end of the first print, continuing to repeat the design by carefully joining end to end, until the twelve-yard length of the paper has all been passed under the press. If the pattern has two or more colours the process must be repeated for each colour.

The paper itself is first covered with a ground of colour. This for a few pieces is done by hand on a table twelve yards long, or, if many pieces are required, by a grounding machine. The paper is sometimes embossed after the printing, or as a first process to the plain white paper. This latter way gives a very rich effect when transparent colour is used, as the deeper parts of the embossing take a darker colour.

There is no comparison between the two processes in finish, still less in output, for while the machine can roughly turn out thousands of rolls a day, there are hand-printed designs where skilled printers cannot exceed one hundred pieces a month.

Stencilled papers are usually worked in conjunction with hand blocks. The stencils are cut in zinc and the colours worked into the outline printed usually by block.

Embossed papers are produced by two rollers—one in relief and the other sunken—which impress the paper as it passes between them.

In reviewing the history of English wallpapers it is impossible not to refer to William Morris, who probably did more than any other craftsman to give a new impulse to the production of wallpapers. He devoted much of his attention to its design and printing, and proved that by giving patterns right in structure, character and selection of colour, wallpaper designing was worthy of the attention of the best designers. His earliest work was characterised by a charming straightforward simplicity, though later his designs were more demonstrative of line, yet it is his earlier work which is again in demand. Morris was a man of immense power and not merely a soulful paperhanger and decorative dreamer of dreams, as we might suppose by the utterances of some of his admirers. His work was the evidence of his convictions, and he applied his sense of design not only to wallpapers, but to poetry, and ultimately to life. The "Trellis" paper was the first of the Morris wallpaper designs, though it was third in order of production, and it is an interesting sidelight on the character of the man that with the bird forms he preferred to have the co-operation of another designer, Mr. Philip Webb. Owing to delays in cutting, however, the first paper actually to be printed and sold was the "Daisy," an incident worth mentioning, because this design heads the sales of the Morris wallpapers practically without a break for half a century. This has established what may be considered a record in the popularity of a single design.

There is a pattern book available here containing his designs, and from it you will note that the colours employed are neither few in number nor low in tone, yet they are combined with such skilful judgment that the harmony is perfect. Many of his designs are so reticent in colour and line that they function readily enough as backgrounds to decorative accessories. In designing he ever kept before him the limitations of the medium in which he sought to express himself, as well as the purpose for which it was to be used.

Not only by his pencil, but by his pen as well, he showed how important is the artistic treatment of wall spaces, for in his lecture on " The Lesser Arts of Life " he insists that . . . . " whatever you have in your rooms, think first of the walls ; for they are that which makes your house and home ; and if you don't make some sacrifice in their favour you will find your chambers have a kind of makeshift, lodging-house look about them, however rich and handsome your movables may be." Then later : " I am bound to say something on the quite modern and very humble, but as things go, useful art of printing patterns on paper for wall hangings. But really there is not much to be said about it, unless we were considering the arrangement and formation of its patterns, because it is so very free from those difficulties, the meeting and the conquering of which give character to the more intricate crafts."

Largely through Morris's influence many decorative artistes entered this branch of domestic ornamentation. To name only a few—Messrs. Voysey, Walter Crane, Heywood Summer, Lewis Day, Arthur Silver and George Haité.

I have had slides made of some of these designers' work, and also a few of Mr. Horace Warner's, of Messrs. Jeffrey and Co., which for beauty of line and colour would be difficult to surpass.

From all indications, it seems to be evident that we are soon to witness a reaction on the part of the public in favour of patterned walls.

We are all too painfully familiar with the conditions which demanded relief from sadness and privation, and found it in extreme design and riotous colour. Nothing in those days seemed too extravagant in colour arrangement or too " wild " in *motif*—anything to obliterate the memories of evil times.

Viewed in the light of the conditions that produced such a demand, allowance can be made for the freakish and *bizarre* effects that were the vogue immediately after the war. That phase of colour decoration went gradually and completely, and with it all the jazz arrangements of stripes, circles and triangles.

As with any revolutionary movement, failure is bound to result where basic principles of order and discipline are ignored. The outcome was a demand for simplicity in colour and design, which soft goods manufacturers readily availed themselves of to bring forward a range of designs that demanded as offset a severely plain background. They are to be congratulated on their preparedness to so quickly supply the anticipated want. Art societies, which, for a long time had been combating the superstition that real art depended on elaborate and heavily loaded ornament, welcomed any revolt against the Victorian period, and saw in it the prelude to a return to simplicity of pattern and colour. By exhibitions and in print they consistently heralded the approach of the time when " blue ribbons and pink roses " would be an abomination to the average home owner. They viewed the exotic phase of the change as in the order of things—as a sign of life and a reverson to former ideas and types. It is remarkable, is it not, when we think of the Victorian period's quest after realism, of the present return to an extreme of simplicity. And we might be thankful it came via the Jazz period, for to-day we have gay but ordered colour, with a delight in frank and simple patterns. Furthermore, there are evidences of an awakening interest in æsthetic matters generally. The national æsthetic impulse has seemingly been quickened. There is a conscious improvement in the relationship existing between the artist and the manufacturer. One has only to go through our leading departmental stores for proof of this, and there see the wealth of artistic goods and materials displayed. The manufacturer has discovered that artistry in his products is a commercial asset, and is increasingly employing men of proved ability in the field of design, whilst the artist, craftsman and designer has recognised that he must accept the prevailing industrial conditions, and that if the public taste is to be improved his artistic abilities must find expression by mastering the machine, for by it alone will the art that will minister to national demands be met.

Craftsmanship to-day means the production of efficient things; it stands for art service—service bringing grace and beauty to accessories of everyday life. Unfortunately, the great interest being shown in interior decoration has inspired many enterprising journalists and facile writers to pose as experts, writing most ingenious articles on every phase of home decoration, with the result that we have quite a host of so-called authorities on decoration, and quite a number of periodicals concerned wholly with the home and its appointments. Often, it is to be feared, ignorance of the wealth of decorative materials was the reason for their proclamation of the gospel of bare walls, but the average home owner is a person who wants his home to be a pleasure to himself and his friends and to reflect his interest in its decorative treatment, and whilst he will refrain from vulgar display of possessions, he will not go to the opposite extreme and live between bare walls, for he has found out that there is added warmth and comfort when the walls are covered with a carefully selected texture or patterned wallpaper. We do well to remember that overstudied simplicity may become as baneful as the over-elaboration of yesterday.

Wallpaper manufacturers to-day produce a wide range of plain effects in all manner of pleasing textures, so there is available a choice of papers to satisfy even the most insistent advocate of the plain wall.

Nevertheless, however high their intrinsic qualities, wallpapers *must* be considered in relation to the objects in proximity to them. Walter Crane, in his "Ideals of Art," aptly says :—

> "Relationship is, of course, the essential in all decoration, otherwise it becomes a patchwork of conflicting pattern and colour. It matters not what our materials may be, or by what means, costly or simple, we seek to obtain our effect—whether by painting, carving, gilding and rich textiles, metal or plaster work, stamped leather or wallpaper, stencilling, tiles and

plain painting or stained wood and whitewash—all must be in keeping and seem fit and in its right place and proportion, and suitable to its conditions and surroundings."

Whether drawing rooms, music rooms, halls, living rooms, bedrooms or studies are in question, or whether we are considering plain papers and borders, patterned papers and stilings, or allover designs, it is essential that the furnishings of the particular apartment should be properly considered in relation to the choice of background. The function of the room should be considered, its method of lighting, its architectural features and general immediate surroundings. Some rooms are required to give the feeling of rest and quietness ; others gaiety and motion. A dining room, for instance, should look a suitable place to eat in ; a living room to live in, with a refined, quiet and otherwise pleasing atmosphere. Bedrooms should be restful and light. Be assured that if the wallpaper scheme in the dining room is so insistent that it is disturbing while you eat, it is wrong in selection ; if the lines and motifs in the living room wallpaper are worrying and unrestful, it is in bad taste ; or if the wallpaper in the bedroom is so riotous in colour and full of movement as to give anything but an atmosphere of repose and contentment, it, also, is in bad taste. The following mental questions are suggested as useful aids in determining the choice of wallpaper for any apartment :—

1. Is the wallpaper to be *the* decorative feature or only a background for pictures and other decorative accessories in the apartment ?
2. What description of wallpaper filling design will best accomplish this main object ?
3. Is it fitted for the purpose for which the apartment is used ?
4. Will the pattern, scale, and colouring be in harmony with furnishings, objets d'art, etc.?
5. What method of treatment would be most suitable to the general features of the room and to the character of the filling design under consideration ?
6. Does it also materially enhance the beauty of the filling design as well as of the room as a whole ?

As to the methods of treatment of wallpapers, they can be as varied as the ingenuity of the decorator can devise. If a plain or textured paper is to be used, it may call for a border, and this can be treated in a variety of ways. The border can be used to make each wall one large panel ; or each wall into a series of carefully proportioned panels. Or, again, the border may be placed below the picture rail, or with a second the same distance above the skirting board. If a patterned paper is selected, the room may call for a stiling, the width of which will be determined by the type of filling design and size of the apartment.

It is in this province that we can do with paper what cannot be done so well with plain paint. The too lofty room may be apparently lowered; the low ceiling raised; the narrow room made to appear wider, and the room that is too wide narrowed. As a rule, panelling, whether by stile or border, is not suitable for irregularly shaped rooms; or for the room crowded with furniture. It will further dwarf a small room, but proves most successful in drawing-rooms and bedrooms. Staircases also are not so well adapted for panelling. In the selection of suitable papers for panelling purposes, it must be remembered that the most pleasing effects are to be had with simple designs and colourings. Unless the filling is quite plain, the stiling should be plain, save at the edges. The "Chinese Stile" decoration, of Messrs. Heffer Scott, which I have here, is an example of the decorative note being centred in the stile, and there are other instances where the whole of the interest is in a richly-designed motif placed in an extra wide stile instead of the filling. In all panelling work it is imperative that the decorator is acquainted with the intended position of the furniture.

But, giving far greater scope to the enterprising decorator are the papers which allow of motifs being cut from them to build up decorative schemes, as the apartment will allow and his fancy dictate. Nearly all of the makers' sets contain some designs at least that will allow adaptation for cutting out purposes. You will see, amongst the specimens available, examples from a series of papers which are specially designed for such purposes; and I have on the table portfolios containing a wealth of ideas for building up schemes. In this particular range of designs the makers produce cretonnes to match, thus further assisting the interior decorator.

Quite a new departure in wallpaper design is the "Guinevere" decoration on view, which is produced by my firm. Here the idea is to provide a note of glowing colour in one corner of the room and to link that up along the top of the skirting board. It is a departure from the generally accepted idea of wallpaper decoration. The "Midsummer Night's Dream" has a similar purpose, and provides an ideal decoration for a boudoir. Beyond question, there is no more important consideration in the decorative scheme than colour. So engaging has the subject become that even the wife of our present Lord Chancellor and Counsellor of State can write in the columns of the evening press on the subject of colour and its effect upon health. Women are discovering that their innate abilities of discrimination, selection and comparison, used to express their personalities to others in dress, can also be turned, and with greater advantage, to minister to their own individual comfort, and that by the intelligent choice of colour in the home they can equally express their personality.

Colour is analogous to music. It has the power to affect and work upon the passions of the mind. Who has not been impressed with the glowing sunset or the many-hued rainbow against the thunder-grey sky? A person of refined susceptibilities would find it impossible to live with a discordant colour arrangement. This is, therefore, another vital factor determining wallpaper selection; for the apparent size of the apartment can be affected by the intensity and value of the prevailing colours used, light or dull colours conveying size, and the stronger and darker colours making it appear smaller. It is unfortunate that there is not an accepted standard colour chart, for some of the so-called "fashionable" colours would baffle the most expert salesman, "Elephant's breath," for example.

A decorator possessed of a knowledge of the psychological effects of colour and a trained colour sense will have the right colour, or combinaiton of colours, in the right place. He will select it for its fitness of purpose, and further see that it is in right proportion.

Yellow—the colour of sunlight—has been much in demand, and is particularly useful for lightening dark rooms. Colours also composed of a considerable amount of yellow are all luminous and light-giving.

Blue, which seems now to be the colour in demand, is retiring and soothing in its influence. In some shades it is cold, but in all gives spaciousness.

Reds, of the vermilion order, are exciting and advance; that is, they have a tendency to come forward and make walls appear nearer and thus apparently dwarfing the size. All reds, however, have a quality of warmth.

Orange is expressive of heat, and if too large a proportion of red enters its composition becomes irritating.

Green is restful.

Purple is regal, but the most retiring of all the rich colours.

Certain colours are associated with certain periods, and if a period decorative scheme is in question should be followed. Of course, even among the best decorators, there is a divergence of opinion regarding colour and colour combination—due probably either to temperament or individual colour sense. This may apply alike to intensity of colour, strong colour being a delight to some and nausea to others.

But, in any case, there is no necessity for white and drab schemes. Colour in the home is productive of joyousness and life, and its uses give an opportunity to express personality. Two useful principles to bear in mind are:—

1. Wallpaper backgrounds should be less intense in general colour than the objects that are to appear against them in any decorative way, and its corollary,—
2. That the larger the colour area the less intense it should be; the smaller the area the more intense it may be.

For the sake of any young designers present I would have liked to have quoted at length from William Morris's lecture, "Making the best of it," for in it he has some most useful hints on the structure of patterns, but a few of his general observations will be helpful:—

> "In all patterns which are meant to fill the eye and satisfy the mind, there should be a certain mystery. We should not be able to read the whole thing at once, nor desire to do so, nor be impelled by that desire to go on tracing line after line to find out how the pattern is made, and I think that the obvious presence of a geometrical order, if it be, as it should be, beautiful, tends towards this end, and prevents our feeling restless over a pattern.
>
> "Everyone who has practised the designing of patterns knows the necessity for covering the ground equably and richly. This is really to a great extent the secret of obtaining the look of satisfying mystery aforesaid, and it is the very test of capacity in a designer.
>
> "Remember that a pattern is either right or wrong. It cannot be forgiven for blundering. It is with a pattern as with a fortress—it is no stronger than its weakest point. A failure forever recurring torments the eye too much to allow the mind to take any pleasure in suggestion and intention.
>
> "As to the second moral quality of design, meaning, I include in that the invention and imagination which forms the soul of this art, as of all others, and which, when submitted to the bonds of order, has a body and a visible existence. Now, form may be taught, but the spirit that breathes through it cannot be; so I will content myself with saying this on these qualities, that though a designer may put all manner of strangeness and surprise into his patterns, he must not do so at the expense of beauty. You will never find a case in this kind of work where ugliness and violence are not the result of barrenness and not of fertility of invention. The fertile man—he of resource—has not to worry himself about invention. He need but think of beauty and simplicity of expression; his work will grow on and on, one thing leading to another, as it fares with a beautiful tree."
>
> "You must not only mean something in your patterns, but must also be able to make others understand that meaning. Now the only way in our craft of design for compelling people to understand you is to follow hard in Nature; for what else can you refer people to, or what else is there that everybody can understand?—everybody, that is, worth addressing yourself to, which includes all people who can feel or think."

But the designer of real ability will seek for new ideas from every conceivable source—in and outside of museums; from jewellery; store windows; books and textiles—not only for motifs and arrangement of pattern, but also for new treatments in wall decorations generally.

Most of the manufacturers have their own staff of designers—men who are in actual contact with the factory, and conversant with all the possibilities and limitations of wallpaper printing—but designs *are* bought from free lance designers, though the successful men could be counted on the fingers of one's hands.

From the manufacturers' point of view, I am convinced that it is a short-sighted policy simply to regard wallpaper from a utilitarian point of view, and on that ground alone to work for its universal use. Temptations lie in that direction to disregard artistic quality which would inevitably re-act against their use. They do well to remember, however, its wide use, and see in that their opportunity to develop the public taste.

One of the manufacturers' and merchants' main difficulties is the lack of really skilled paperhangers—men of skill and taste who can intelligently handle their goods. American manufacturers have already tackled this problem, and have combined in an educational campaign for the training of paperhangers, and I believe some such scheme will have to be evolved for the trade here.

But the happiest omen of the present phase is that the decorator—the man who handles the wallpaper—is beginning to realise that he must specialise, and that the younger men entering the decorating trade should be given a training in art as well as in the theory and practice of their craft.

The art of interior decoration is one which calls for knowledge of materials and a keen appreciation of the principles and traditions which make for beauty and usefulness. It is essentially an art which calls for the exercise of a high standard of artistic judgment and feeling, for whilst the easel artist can comfortably correct his painting or drawing, error in judgment by the interior decorator is costly both in time and materials. Knowledge is power, and there is no excuse for asserting that it hampers originality.

The decorating trade does well to concentrate on the training of its younger men, for decoration is now one of the most promising and modern of the professions. That there is an upward trend in decorative matters generally is encouraging, but greater impetus would be given to this general improvement if salesmen and others engaged in the furnishing trade, and wallpaper houses in particular, could be persuaded to undergo a course of specialised instruction in the principles governing good decoration, and doubtless this could be accomplished once it was demonstrated that an acquaintance with the styles and vital principles is essential to the 100 per cent. salesman. A more intimate knowledge and appreciation of what is good would certainly make for greater enthusiasm, and salesmen would thus become greater factors in the advancement of good design. It can scarcely be challenged that the retail salesman exercises a larger influence in affecting the quality of the thing sold to the customer than that coming from any other quarter.

The æsthetic quality of the product that actually finds a place in the household of this country is for this reason dependent to a very large extent upon intelligence and artistic appreciation in these persons.

Though we have little to learn from America as far as design for textile or wallpaper is concerned, resolute co-operative efforts are being made there for definite progress in artistic development. In 1920 a very careful survey was made of the manufacturing industries in which design exercises a relatively important influence, amongst the industries being that of wallpaper printing. Coinciding with the trade survey, a study of the work in "applied design," represented by the art schools of the country, was made, and the report will undoubtedly prove an invaluable guide in the improvement of American methods in the training of designers for the respective trades.

If some such report could be instigated in this country I am confident much practical good would result, and that instead of the present callous criticism of our Government art schools, practical co-operation on a systematic basis would result between the manufacturer and these institutions. Criticism, to be of any good value, *must* be sympathetic.

From the English wallpaper manufacturers' standpoint I believe there is a genuine endeavour being made to eliminate bad designs, and to search for new designs and materials that will ensure a continuance of our national lead in this important art industry. There is ample justification for the "reason why" advertisements now being issued by the English manufacturers, and their claim to produce the best wallpapers.

[The Paper was illustrated with 70 slides and many specimens of wallpaper.]

DISCUSSION.

THE CHAIRMAN was sure the audience would agree that the paper had been a most interesting one, and that the author in reading it had held their attention spellbound the whole of the time. He had been wondering what his qualification was in occupying the Chair, and he could only think that it must be that for more than 50 years it had been his painful duty to attend on lady clients when they were selecting wallpapers for their houses; and from his experience he had the very greatest sympathy and respect for the salesman in such circumstances. He wished it were possible to have an exhibition of the excellent wallpapers shown by Mr. Dowling, say at an Ideal Home Exhibition, in order to train the general public to appreciate and desire those designs, because it was really most trying when clients insisted upon having the things which they did select.

The lecturer's reference to sympathetic colours reminded him of a little incident which had happened to him some years ago. He had had to build a house for one of the Sheriffs of the City of London. He had just got to the decoration part of it when his client had assumed his year of office. The Sheriff's wife had strong tastes in colour, and had selected for the bedroom a greenery-yellow paper. The first night the Sheriff returned home from his first official City dinner he had occupied that particular room, and woke up in the middle of the night with a most abominable bilious attack, which he attributed to the wallpaper, but which was no doubt due to other things.

With regard to the much maligned paperhanger, he was tempted to ask whether he had a very free hand in the matter. He could, of course, hang things upside down and that sort of thing, but really he did not come on the scene as a rule until after the paper had been selected; and he did not get very much opportunity of exercising any choice or discretion.

Mr. Horace Warner proposed that a hearty vote of thanks should be given to the author for his paper. He was afraid he could add nothing to what the author had said, but he had greatly appreciated the lecture.

Mr. A. V. Sugden desired to state with what pleasure he had listened to the paper, and how much he appreciated the enormous labour which the author must have put into it. He would also like to remark that Mr. Dowling had presented a most wonderful selection of slides, which had been of very great assistance in illustrating the points contained in the paper. The English wallpaper industry, as the author had shown, was of very considerable antiquity. Wallpapers had been produced in England as far back as the beginning of the 16th century, and just lately an American authoress had attributed to England one which went back to 1425. His own colleagues and himself were trying to trace that particular paper so as to confirm if possible that attribution, and if they were successful it would prove, he believed, to be a sort of attempt to portray St. George in flock. The use of flock for the embellishment of cloth probably dated to about 1290, and the use of flock on paper went back to as early a date as 1455.

He thought the author had been very wise to emphasise the influence of William Morris. William Morris had restored to the English industry a supremacy which had previously passed from England to France. He, more than any other man, had brought back that supremacy to England. He had been followed by a wonderful band of men; Walter Crane was probably his nearest successor, and was a most wonderful artist, in addition to being a very wonderful wallpaper designer. Then had come Lewis Day, who possessed a perfect genius for patterning. He did not believe Lewis Day had ever drawn a pattern which did not repeat perfectly and, what was even more important, which did not repeat in such a manner as not to annoy. One of the most annoying things about a wallpaper was a bad repeat. Lewis Day, always in the most clever and artistic manner, concealed his repeat, which was, after all, a necessity in mechanical production. Then came Mr. Voysey and a band of artists who had done probably more than any others to bring English wallpaper to the front. Just before the war there had been an extraordinary period when the frieze had come into vogue; the ingenuity of ideas and subjects used in frieze was probably as remarkable as anything which had ever happened in wallpaper history. The frieze had worked itself out by sheer over-enthusiasm. Every kind of motif had been used. Nothing had been sacrosant; everything had been dragged in to serve the vehicle of the designer, and the result of the frieze becoming such a dominant note had been that wallpaper grew extremely quiet, and the pattern had almost disappeared. Then came the war, during which the wallpaper manufacturers of this country had been very largely engaged in the manufacture of munitions. After the war there came that horrible period to which the author had referred—the nondescript sort of period of " jazz," and so forth, which had happily now disappeared.

The war had taught English wallpaper manufacturers how unwise they had been to have become so dependent on the foreigner for designs. The French had always been and always would be supreme in certain types of flower design and period stuff; but the English wallpaper industry had come to lean on the Germans because the Germans were so clever at saving trouble. The German designs had been extremely easy to cut or engrave, and the English industry had neglected the English designers simply on account of the cleverness of the German designers in saving trouble. However, the war had made it necessary for the English industry to train its own young designers—very often ladies, because the young men had had to go to the front. As he had said, the industry had had to give a good deal of attention to the training of English designers during the war, and the result had been that, although the industry was open to buy designs from all parts of the world, the merit of the English designer was such that not more than 1 or 2 per cent of the designs now came from abroad.

He thought the industry was extremely fortunate at the present time in having several houses, including that which the author served, which were doing a tremendous lot to uphold the craftsmanship of the trade and the artistic value of wallpaper. He hoped and believed that amongst the gentlemen who were contemporary with themselves they would have such a band of wallpaper manufacturers as would also leave their mark very honourably on the pages of wallpaper manufacture history.

Mr. W. G. Raffé said that one point had struck him very recently in seeing some of Messrs. Green and Abbott's interesting Chinese papers, namely, that the cycle of wallpaper manufacture seemed to have turned the whole circle in its development, back to small sheets of paper, which had been made by the old manufacturers simply because they could not produce longer paper like that which was made at present, and to which the industry was now returning, not only in Chinese papers, but in many of the details of ornament rather than repeated pattern. With regard to the point of insistence upon colour, he had seen very many wallpaper patterns which had appealed to him as being excellent designs, but which had lost in colour value by one of the tints used; and it had always struck him that if only the manufacturer had employed some really sensible colour man to overhaul not the pattern but the actual inks used in the printing, perhaps one alteration only could have made the difference between success and failure. There was one very important point in connexion with wallpaper patterns, and that was not only to get the right colour in the rooms but to light the rooms properly. The importance of illumination on decoration was so great as to make it worth while to employ an expert in that direction. With reference to the Chairman's suggestion that wallpapers should be shown at Ideal Home Exhibitions, at the forthcoming Wembley Exhibition in the Engineering Section there were going to be a number of completely built houses exhibited, and he hoped some steps would be taken by wallpaper manufacturers to show the latest developments of their trade there.

Mr. Bernard Donald said he could only add his word of appreciation to those of previous speakers, and say how delightful it had been to hear the author speak on a subject with which he was so very well acquainted and in regard to which he was so well qualified to teach many of those in the industry. The author, in the course of his paper, had said so many things towards stimulating interest in the actual creation of the article with which he had dealt that the industry should be extremely grateful to him. Those who enjoyed form and colour in the article itself were extremely apt to forget what tremendous brainwork and thought had gone to the creation of that article. No doubt a price was paid for it, but in many cases that price was absolutely out of proportion to the wealth of pleasure given by it. It was very often distressing to see the very small amount of recognition given to the great work and thought which was put into wallpaper designs.

Mr. A. B. Sanderson expressed his great pleasure at being present to hear the lecture. He was one of the author's opponents in business, and as such he could perhaps appreciate more than some of the other members of the audience the enormous amount of work and labour which Mr. Dowling had put into his paper, MR. JOHN CHASNEY remarked that, although Mr. Dowling had seemed to have dealt with the subject from the very beginning to the end, he thought it would be generally felt that he had given rather an idea that there were still greater things in store for the industry in the future than had ever been produced in the past. William Morris might have given the industry a great inspiration, but personally he did not think it had yet finished with inspiration, and that there were still greater things to be done in the future in regard to wallpapers than had ever been done in the past. When the industry got, on the sales side, men with such intelligence, skill and thought as Mr. Dowling, there was some hope for the manufacturers to continue to try to produce better stuff. There had been a tendency on the part of the manufacturers to get depressed because sometimes people did not know how to use the material which had been produced. If they could get lectures of the present kind which would put before the public the real merit of wallpapers and what wallpapers could do to make the home beautiful and attractive, there was no saying to what limits the industry could go.

MR. EDGAR SMITH said there was one point he would like to mention, which, he thought, would interest those present. As the slides were shown he had thought what a pity it was that the work of an artist should be so easily lost and forgotten. The artist put his whole soul into his design, and possibly received a fee of ten guineas for it although he put £100 worth of real thought into it. It then went on to the rollers and was sold on paper for a period of two or three years. Then the walls got old, and the machinery which printed it was turned off to make other patterns. The result was that that very beautiful design was lost. In this country there were people who collected works of art—pictures, glass and so on—but it was a very rare thing indeed to come across anybody who collected old wallpapers. He dared to prophesy that if any man had a collection of things as beautiful as those which had been shown on the wall that evening, in a century's time they would be of inestimable value. He desired to give that " tip " to those present.

MR. B. PHELPS said decorators looked askance at the wallpaper manufacturer because they always felt that wallpaper decoration never fully gave them a medium by which to express not only their individual artistic needs but those of their clients. The author had shown that night, however, that like many other things, wallpapers had certainly evolved for the better. It was in the line of modern ideas which the author had pointed out, namely, the adaptability of designs to the needs of the decorator wherein lay the hope of the wallpaper manufacturer. He was very pleased at the significance which the author attached to the need of co-operation between the manufacturer and the artist, and there was evidence to-day that that co-operation was taking place.

MR. C. RENTON drew attention to the fact that present-day conditions were forcing a number of people to decorate their own homes. The Press from time to time published spasmodic articles on how to decorate the home. He believed more often than not that those articles were not always correct and led a good many people into taking a wrong direction in the matter of decoration. He thought it should be the policy of the Association of Wallpaper Manufacturers to appoint a writer who was capable of dealing with all decorative subjects, and of writing inspired articles for the Press, teaching the people how to decorate their homes in a proper manner; 99 per cent. of the people to-day did not allow themselves sufficient time in which to decorate a room properly. They wanted a wallpaper which they could handle quickly, and they had not the slightest idea of how to hang paper so as to create an artistic room. A great deal had been done at the Ideal Home Exhibition, and those efforts were already bearing fruit. He thought if there was a greater publication of articles dealing with decorative schemes, issued by the Association of Wallpaper Manufacturers and by merchants in general, a much better tone of paper would be used by the public. Another point was that merchants should pay more attention to wallpapers in their sales rooms. At the present time the exhibition of wallpapers in showrooms was infinitesimal, and moreover very often dirty looking wallpaper was exhibited which did not encourage persons to go in to view artistic decorative schemes.

MR. HORACE WARNER, in reference to what Mr. Smith had said about collections of wallpapers, said he did not know that manufacturers would altogether welcome such a suggestion. Some years back, when a similar lecture had been given, it had been stated that if those present would care to write to the firm of which he was a representative and ask for a collection of Walter Crane's and Lewis Day's designs they would be supplied with specimens. The result had been that the firm was inundated for weeks and weeks with requests from all over the country. Therefore he would suggest that instead of private collection of wallpapers there should be a national collection, which should be housed in the various museums of the country, and could be added to year after year. That, he thought, would be extremely valuable to the nation, and those interested in the subject could go to those museums and study the subject.

MR. H. F. BUTTON remarked with regard to the suggested collections of wallpapers, that it would be well for wallpaper manufacturers to put a price on any specimen which was asked for. That was being done by the Underground Railway in connexion with their posters, some of the earliest of which, he believed, were now worth something like ten or twelve guineas. A price of four guineas was put on some of the more recently printed posters. Therefore patterns of wallpapers might be made very valuable if a price was put on them.

THE CHAIRMAN, in closing the discussion, mentioned that Prof. Beresford Pite, who once read a paper on the same subject, began by saying he would not apologise for the humble nature of his paper, because after all the subject was the background of our social life. He (the Chairman) thought that was very true; people always had to live with their wallpapers.

The Royal Society of Arts had a very interesting competition of wallpaper design, in connexion with its forthcoming Annual Competition of Industrial Designs, and he hoped that the present lecture might be the means of stimulating students to come forward and compete. The Society also had a very interesting painters' scholarship called the Berger Scholarship, which, he thought, might be taken note of by some of the younger members present.

The vote of thanks was then put and carried unanimously.

THE AUTHOR, in reply, thanked the audience very much indeed for the reception which they had given to his paper. He invited them to inspect the various designs and blocks which he had brought with him. Regarding the remarks made in connexion with collections of patterns, he might say that he was very largely engaged on that himself. He had a delightful collection of some of Mr. Horace Warner's designs, which he prized as much as any beautiful pictures or etchings. He thought it would be wise on the part of manufacturers as a body if they prohibited patterns going out without any cost. The time involved in getting together a set of patterns was enormous. He had been very interested in the remarks made by Mr. Raffé concerning colour, in which subject Mr. Raffé was an expert. He had also been interested in the remarks made on the time which should be given to selection. There were one or two factors determining that. In the average showroom when a hundred or more clients were going through the room, time could not always be given by the merchant or the manufacturer to deal with the subject adequately, and an average selection was made in a haphazard way. He thought if salesmen were to devote some time to the study of the subject, and if attention was given by the manufacturers to the training of the salesmen and to a real educational campaign, such as was now carried on in America, improvement in that respect would gradually come about. It was noticeable that improvements were taking place, and although some of the articles appearing in the Press were inspired, yet the attention of the manufacturers to really efficient work in that direction should certainly be given.

OBITUARY.

VISCOUNT LEVERHULME.—By the death of Lord Leverhulme, which took place at his residence, The Hill, Hampstead, on May 7th, the Society has lost a Vice-President and a friend whom it will not be easy to replace. He made his first appearance here in 1917, when he spoke in the discussion on a paper by Dr. M. Horn on "The Economic Development of the Belgian Congo." In the following year he read a paper himself, his subject being "'Zero' of Capital and Labour," and at that time he was elected a Life Fellow of the Society. In 1918 he again spoke, the occasion being a meeting called to inaugurate a scheme for the Improvement of Industrial Art, a subject in which he took a warm interest, and on which no one was better fitted to speak than he, both on account of his knowledge of the art of advertising (in its best sense) and because of his natural genius for appreciating artistic merit. He was also elected a Vice-President of the Society in 1918, and he continued to hold this office, with a brief interval, up to the time of his death. Owing to deafness he was not able to attend meetings of the Council frequently; but he was always ready to give his advice and assistance when the Council desired to consult him, and he was one of those good friends of the Society who started the fund to purchase its House, his contribution being a thousand pounds.

William Hesketh Lever was born at Bolton in 1851. At the age of twenty he entered his father's grocery business; ten years later he resolved to start for himself, and opened a grocery shop at Wigan. After five years' work he sold this business for £60,000. He then decided to strike out on a new line and became a soap manufacturer. "Sunlight Soap" came into the world at a little factory in Warrington, but by 1888 its success had led to the establishment of the great works at Port Sunlight, and later on to associated factories on the Continent, in Australia, Canada, the United States—in short, all over the world, linked up with coconut plantations on the Pacific, in Africa, and with branch offices and agencies everywhere.

The history of Lord Leverhulme's rise from humble beginnings to the first rank of industrialists is one of the finest romances of British commerce. It has been told so often during the last few days that there is no need to repeat the details here. His amazing success was due entirely to his own energy and genius. His working day began long before most of us thought of getting up, and he made such good use of his time that, however much pre-occupied with business or public affairs, he never appeared to be hustled or overwrought.

Whatever Lord Leverhulme undertook was done on a grand scale. His magnificence was princely. He presented to the nation Stafford House, with much of its furnishings, as a home for the London Museum. Liverpool University owed much to him, especially its Schools of House and Town Planning, of Tropical Medicine, and of Russian Studies. His native town of Bolton was not forgotten by him, and he showered gifts on Port Sunlight, including the Lady Lever Art Gallery, in memory of his wife.

Mr. Lever was created a baronet in 1911, raised to the peerage as Baron Leverhulme in 1917, and in 1922 advanced to a Viscounty.

NOTES ON BOOKS.

Crop Production in India.—A critical survey of its problems by Albert Howard, C.I.E., M.A. Oxford University Press, 1924. Pp. 200. 10s. 6d. net.

This book is both refreshing and stimulating, inasmuch as the subject is approached from an unusual angle. Crop production, that is the high return which the cultivator desires, is dependent on the correct adjustment of the plant to the environment and especially, as this is the variable factor of the environment, to the soil. Root development is, consequently, a matter of primary importance and a matter for detailed study. On the one hand is a study of the soil conditions and, on the other, the study of root development as a plant character. And, when a critical survey of the literature of work on crops is made, it becomes a matter almost of amazement how little attention has been devoted to the root and how much to the stem. Crop production, therefore, will be best assisted, by the study of root formation as a specific plant character capable, though possibly with difficulty, of analysis and by the study of soil conditions best suited to the particular root formation. This central thought find sits full expression in Chapters VI and XIX on the Economic Significance of Root Development and Disease in Plants—"There seems little doubt that the most promising method of dealing with disease is by means of the plant," "varieties differ greatly among themselves in resistance to disease" and "Resistance to disease can be increased or decreased . . . . by alterations in soil texture."

Next in importance to a study of the root, therefore, comes the study of soil management and here the key to the position is to be found in soil aeration. "The full significance of soil aeration in agriculture is only now being recognised" (Chapter II), and it must be admitted that the importance of this aspect and the comparative neglect of this field of study fully justify the insistence laid on the subject, even if in the process the point appears to be stressed too much. The discussion of this chapter leads up to a consideration of irrigation, the nitrogen problem and the alkali problem.

The major portion of the book consists of a series of chapters on the major crops of India each containing a description of the work done by the Agricultural Department of India since its establishment by Lord Curzon in 1904 and an indication of the problems most urgently awaiting investigation. As has been indicated, in these the question of soil aeration is given a prominence which many will consider to be more than its due.

The book concludes with two chapters on organisation, discussing the Ideal Investigator and the Organisation under which he can work with best results.

Investigation is so much a matter of individual temperament that it seems rash to lay down that "after adequate scientific training the future investigator of crop-problems must master the art of agriculture." Were we to have to express an opinion, we would say that there is so much in the art of agriculture that is absorbed rather than deliberately learned that the best investigator is most likely to be found in one who has been bred in agricultural surroundings and learned his science later.

There can be no doubt that work such as it is the whole object of the book to stimulate is best conducted indirectly and not by direct Government agency. Whether, as is suggested, such a system can be built up in India is perhaps open to doubt.

RAILWAY DEVELOPMENT IN NEW ZEALAND.

In his recent annual Report on the economic and commercial conditions of New Zealand, His Majesty's Trade Commissioner in the Dominion states that during the last financial year the Minister for Railways made a very complete personal inspection of the whole of the State railway system, and his forthcoming Statement is expected to lay down a programme for systematic development of the service during the next few years. Such a programme in conjunction with a considered plan of road development such as is to be undertaken by the newly constituted Highway Board will do much to open up new country and prepare the way for the extension of closer settlement and more extensive production. Such a development might make it possible to permit of immigration on a considerably larger scale.

The Government has secured the services of two British railway experts to enquire into and report upon the organisation and running of passenger and goods traffic and matters relating to the mechanical operation of the system, including construction, renewal and maintenance of permanent way. It is expected that they will be able to make recommendations of great value to the management of the railways. The Minister for Railways also has under consideration the question of electrification of suburban lines and it is expected that he will shortly make an announcement of his proposals for development in this direction.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesdays :—

MAY 20, at 8 p.m.—PROFESSOR JOHN AMBROSE FLEMING, M.A., D.Sc., F.R.S., "William Sturgeon and the Centenary of the Electro-magnet." ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council of the Society, will preside.

May 27, at 4.30 p.m.—THE RIGHT HON. SIR ALFRED MOND, Bt., M.P., "The Unemployment Problem."

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

MAY 22.—SIR ALFRED CHATTERTON, C.I.E., B.Sc., Assoc.M.Inst.C.E., "The Industrial Progress of the Mysore State." SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S., will preside.

JUNE 12.—BRIGADIER-GENERAL SIR PERCY M. SYKES, K.C.I.E., C.B., C.M.G., "The Heart of Asia and the Roof of the World."

DOMINIONS AND COLONIES SECTION.

Thursday afternoon, at 4.30 o'clock :—

JUNE 18.—HON. W. G. A. ORMSBY-GORE, M.P., Under Secretary of State for the Colonies, "East Africa."

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

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MONDAY, MAY 18..Geographical Society, Lowther Lodge, Kensington Gore, S.W. 5 p.m. Mr. N. E. Odell, "Some Geological and Glaciological Observations of the 1924 Mount Everest Expedition."

British Architects, Royal Institute of, 9, Conduit Street, W. 8 p.m. Mr. G. T. Forrest, "The Architectural Development of American Cities."

Victoria Institute, Central Buildings, Westminster, S.W. 4.30 p.m. Prof. H. W. Carr, "Review of Philosophic Tendencies Since Hegel."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 7 p.m. (Graduates' Section.) Mr. P. W. Thomas, "Some Factors in the Choice of the Best System of Traction for Handling Dense Suburban Rail Traffic."

East India Association, Caxton Hall, Westminster, S.W. 3.30 p.m. Prof. N. N. Gangulee, "The Problem of Rural Life in India."

University of London, University College, Gower Street, W.C. 5 p.m. Prof. G. D. Hicks, "Hegel's Æsthetics." (Lecture II.)
5.30 p.m. Prof. A. V. Hill and Prof. J. C. Drummond, "Bio-chemistry." (Lecture III.)
At King's College, Strand, W.C. 5.30 p.m. Prof. R. Dyboski, "The New Poland." (Lecture IV.)
5.30 p.m. Prof. A. Cabrera, "Prehistoric Paintings in Spain." (Lecture III.)
At the London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m Mr. P. J. N. Baker, "The Economic Reconstruction of Europe." (Lecture IV.)
At Gresham College, Basinghall Street, E.C. 7.30 p.m. Mr. A. Compton-Rickett, "Some Writers of Yesterday and To-day."
Lecture IV.), "A. A. Milne and Noel Coward."

TUESDAY, MAY 19..Statistical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 5.15 p.m. Sir Napier Shaw, "The Week or Month as an Intermediate Time-Unit for Statistical Purposes."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C. 4 p.m.

Photographic Society, 35, Russell Square, W.C. 7 p.m.

Anthropological Institute, 52, Upper Bedford Place, W.C. 8.15 p.m. Dr. R. Ruggles Gates, "Mendelian Inheritance in Man."

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. R. Whiddington, "The Passage of Electricity Through Vacuum Tubes." (Tyndall Lecture.)

Transport, Institute of, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C. 5.30 p.m. Mr. W. Clow, "Goods Train Services and Time Tables."

University of London, at King's College, Strand, W.C. 5.30 p.m. Rev. Canon B. H. Streeter, "Primitive Church Order." (Lecture III.)
At St. Bartholomew's Hospital Medical College, West Smithfield, E.C. 5 p.m. Dr. H. H. Dale, "Chemical Control of Certain Bodily Functions." (Lecture II.)

WEDNESDAY, MAY 20..Meteorological Society, 49, Cromwell Road, S.W. 5 p.m. (1) The late Mr. F. W. Harmer, and Mr. C. E. P. Brooks, "Further Remarks on the Meteorological Conditions of the Pleistocene Epoch." (2) Sir Gilbert T. Walker, "On Periodicity." (3) Dr. H. Jeffreys, "On Fluid Motions produced by Differences of Temperature and Humidity." (4) Mr. A. H. R. Goldie, "Gustiness of Wind in Particular Cases."

Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

Botanic Society, Inner Circle, Regent's Park, N.W. 3 p.m. Lecture on "The Basic Principles of Cosmic Encounters."

University of London, at King's College, Strand, W.C. 5.30 p.m. Mr. H. W. Steed, "Central Europe, Rumania and the Near East." (Lecture III.)
At the London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. Mr. R. A. Smith, "The Metal Ages in Western Europe." (Lecture II.) "The Early Iron Age (Early British)."
At the School of Oriental Studies, Finsbury Circus, E.C. 5.30 p.m. Dr. D. G. Hogarth, "The Origin and Character of the Hittite Civilisation." (Lecture I.)
Lecture II. on May 21.

THURSDAY, MAY 21..London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 5 p.m. Mr. W. G. Bell, "The Great Plague of London."

Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p.m.

Chemical Society Burlington House, Piccadilly, W. 8 p.m. (1) Messrs. P. C. Austin and J. R. Park, "The Rotatory Dispersion of Derivatives of Tartaric Acid." Part II. Acetyl Derivatives. (2) Messrs. J. Kendall and J. E. Booge, "The Stability of Additive Compounds Between Esters and Acids." (3) Messrs. J. Kendall and C. V. King, "Additive Compounds in the Ternary System, Acid Ester Water." (4) Mr. J. F. Thorpe, "The Nature of Unsaturation in Carbon Compounds." Part I. "The Ethylenic Linkage." (5) Messrs. E. H. Farmer, S. W. Switz and J. F. Thorpe, "The Nature of Unsaturation in Carbon Compounds." Part II. "Conjugation (cis-hexatriene)." (6) Mr. H. J. Emeléus, "A Spectroscopic Study of the Combustion of Phosphorus Trioxide and of Phosphine." (7) Messrs. E. L. Holmes and C. K. Ingold, "The Nature of the Alternating Effect in Carbon Chains." Part III. "A Comparative Study of the Directive Efficiencies of Oxygen and Nitrogen Atoms in aromatic substitution."

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. F. O. Bower, "The Natural Classification of Ferns." (Lecture I.)

Constructive Birth Control and Racial Progress, Society for, Essex Hall, Essex Street, Strand, W.C. 8 p.m. Prof. A. M. Carr-Saunders, "The History of the Limitation of Numbers."

University of London, University College, Gower Street, W.C. 5.15 p.m. Prof. J. E. G. de Montmorency, "African Customary Law." (Lecture III.)
5.30 p.m. Prof. A. Cabrera, "Prehistoric Paintings in Spain." (Lecture IV.)
6.30 p.m. Dr. O. Vocadlo, "The Czecho-Slovak Republic To-day." (Lecture V.)

FRIDAY, MAY 22..Royal Institution, Albemarle Street, W. 9 p.m. Dr. T. M. Carpenter, "Metabolism of Man and Animals."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. G. J. T. Walford, "The Photography of Architecture: a Thrice-Told Tale."

University of London, at St. Bartholomew's Hospital Medical College, West Smithfield, E.C. 5 p.m. Dr. H. H. Dale, "Chemical Control of Certain Bodily Functions." (Lecture III.)

Physical Society, at the Imperial College of Science, South Kensington, S.W. 5 p.m. Prof. L. S. Ornstein, "The Intensity of Spectral Lines-Measurement and Theory."

SATURDAY, MAY 24..Royal Institution, Albemarle Street, W. 3 p.m. Rev. E. M. Walker, "Democracy in the Ancient World." (Lecture I.)

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FRIDAY, MAY 22, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

WEDNESDAY, MAY 27th, at 4.30 p.m. (Ordinary Meeting.) RT. HON. SIR ALFRED MOND, Bt., M.P., "The Unemployment Problem." SIR ROBERT A. HADFIELD, Bt., D.Sc., F.R.S., will preside.

TWENTY-FIRST ORDINARY MEETING.

WEDNESDAY, MAY 13th, 1925. (Joint Meeting of the Royal Society of Arts, the Royal Aeronautical Society and the Anglo-Batavian Society.) MAJOR-GENERAL SIR FREDERICK SYKES, G.B.E., K.C.B., C.M.G., M.P., in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Hooper, Lewis John Eric, London.
Krause, Dr. Heinrich, Chicago, Illinois, U.S.A.
Plummer, William Thomas, London.

The following candidates were duly elected Fellows of the Society :—

Fry, Ambrose, Liverpool.
Horstsmann, E. H., Bath.
Jain, B. Trilok Chand, Meerut, India.
Lewis, Walter Basil, Liverpool.
Robertson, R., Beckenham, Kent.
Stock, Peter, J.P., Southport, Lancs.
Wallis-Whiddett, Frederic George, London.

A paper on "The Non-Stop Flight to the Netherlands East Indies" was read in English by MR. THOMASSEN À THUESSINK VAN DER HOOP.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES AND INDIAN SECTIONS.

(Joint Meeting).

THURSDAY, APRIL 16TH, 1925.

SIR CHARLES CAMPBELL McLEOD, Bt., in the Chair.

The paper read was :—

THE BRITISH EMPIRE EXHIBITION.

By THE LORD STEVENSON, G.C.M.G.,

Chairman of the Board of the Exhibition.

You have, I take it, all seen the British Empire Exhibition. You have all read reams about it in the Press of the world. Some people aver that the Exhibition was not properly advertised. We spent in advertising £120,000, and the Publicity Controller tells me that over 200,000 press cuttings concerning it were collected. It is, you will agree, a colossal record, not confined to publicity for an Imperial Exhibition but extending, as valuable propaganda for a great Imperial idea, the unity and development of Empire. That was the great idealistic aim of the men who originally conceived the project. Few of them, I regret to say, survived to see the turnstiles clicking.

It has been said often that the British Empire Exhibition of 1924 was out to show the resources of the British Empire. Great as it was—and I claim it was great in the true sense of greatness—it never, in my opinion, did anything of the sort. Just as we have, as an Empire, only scratched the surface of our heritage, so did the Exhibition but dimly portray the boundless possibilities of our Empire as it exists. The Exhibition never had enough money to do otherwise. If one-tenth of the annual sum spent upon the dole had been given to a responsible body to organise and run an Empire show, I venture to say that the unemployment problem would not stand where it does to-day. Most of you will, no doubt, have noticed that His Majesty's Government have recently set up an Empire Development Committee for the purpose of considering the best means of spending a million pounds a year on the development of the trade of the Empire. I feel sure that had the British Empire Exhibition never been mooted and never been held this Committee would, after considerable deliberation, have recommended an Exhibition as one of the first objects to attain their end. Incidentally I should like to mention that the Canadian Government have a permanent Exhibition Department of State and hold an Exhibition every year in Toronto.

As I have said, reams of matter have been written concerning the British Empire Exhibition, and its educational advantages have been widely accepted. In wondering how best I could interest you in a novel way and avoid catching my pen upon the tatters of a threadbare theme, I have come to the conclusion that probably you will appreciate the Exhibition more fully if I attempt to-day to show you its growth and its development.

Before, however, dealing with the present let us have a look at the past. I think it not inappropriate to show you a view of the Exhibition held in Hyde Park in 1851 in which Her late Majesty Queen Victoria and her Consort, Prince Albert, took such a keen interest. The whole of the 1851 Exhibition covered a total area of 26 acres. At Wembley the Palaces of Industry and Engineering alone covered 25 acres. I am happy to feel that the interest of the Royal Family in this form of presentment of Empire was maintained in Wembley by His Majesty King George, and that this interest has been extended to the coming Exhibition. In just over three weeks from to-day—Saturday, May 9th—His Majesty the King, accompanied by Her Majesty the Queen, will reopen the Exhibition.

It is, I am sure, the earnest wish of all loyal citizens that His Majesty's sojourn in the Mediterranean will have fully restored him to health.

The idea of the Exhibition first matured in 1913 in the fertile brain of that great Empire builder the late Lord Strathcona. It received general favour but, like many other projects, was cast into the shade by the advent of the Great War. It was not until 1919 that the project was again taken up; then it was taken up enthusiastically. The Prince of Wales, who ultimately became our President, and is now one of our patrons, took a keen interest in the proposed Exhibition, and in June, 1920, he sent a letter to a meeting of those interested, held at the Mansion House, announcing that he had agreed to extend his patronage to the undertaking.

An Exhibition when first planned is generally thought out with a piece of paper and a pencil. I should like at this juncture, for the benefit of the people who come after and who plan Exhibitions in the future, to say that to my mind one of the outstanding lessons of Wembley, so far as the construction of an Exhibition is concerned, is that it did not have a road completely round it. I would submit to the architects of the future that one of the main essentials is to lay out an Exhibition more or less on the lines of a cart-wheel with spokes leading up to the hub and a complete road running right round it. In the present case, new roads had even to be built on the only side of the Exhibition available for roads and the picture on the screen shows this work in progress shortly before the Exhibition opened.

Having decided upon your Exhibition, the first thing to do is to find the site. Wembley was chosen, chiefly from the point of view of the rail transport of passengers, it being more suitable than any other available site within easy distance of the Metropolis, in that it is possible for an excursion train to travel from any town in Great Britain direct to either Wembley or Wembley Hill Stations without a change. As it turned out, probably no other site would have been as suitable, for, apart from transport, the Exhibition as originally planned in 1921 would have covered only an area of 67 acres, but the great enthusiasm of the Dominions and Colonies was such that little by little the surrounding country was incorporated in the scheme until the full extent of 216 acres now occupied was reached. This extension would have been quite impossible on other prospective sites. You will recollect that the acreage of the 1851 Exhibition was 256 acres all told. To illustrate better the extent of 216 acres you see on the screen an outline plan of the Exhibition superimposed over a map of London to the same scale. You will notice here that Marlborough House at the end of Pall Mall synchronised with the South West Entrance and that the Savoy Hotel comes within the Eastern boundaries of the Exhibition. Also, the Exhibition from South East to North West stretches from a point near Waterloo Station to the Piccadilly Circus end of Haymarket. You will also notice, by comparing the Palace of Engineering with the adjacent outline of Trafalgar Square, that the former is nearly six times the size of the latter.

My next picture gives you an idea of what the site was like. This picture, which you will agree is not unsightly, is a view looking towards the North-west Entrance as it was before work on the Exhibition was commenced. Against the tree on the left, which is still in the courtyard of what was the Lucullus Restaurant, were photographed many distinguished people during the course of last year's Exhibition. Incidentally, I may remind you that the Lucullus Restaurant this year is being turned into the Wembley Garden Club, which it is hoped will prove a great added attraction. Information regarding the Club and forms of application for membership are now being distributed, and I would strongly urge those who wish to participate in its benefits to hurry up and enrol as members.

You will now see the North-west entrance as it appeared in its completed state.

The next few pictures will, I think, give you a very vivid impression of the sites on which some of the main buildings were erected. First is the site of the Palace of Engineering; next the Palace of Industry; here is the site on which the attractive Canadian exhibit appeared; and now you see the site of the impressive Australian Pavilion. I am sure you will agree with me that it is very difficult to realise that on sites like these there grew up "Wembley," a name which in the minds of millions of people, both young and old, is associated only with stately buildings representing the extent and resources of the British Empire. In fact, to the great majority of the 17 millions of people who visited "Wembley" it is the only Empire they know.

Actual working operations began in January, 1922, with the cutting of the first sod by His Royal Highness the Duke of York, who, I am glad to say, has accepted the Presidency of the Exhibition this year in place of his brother, His Royal Highness the Prince of Wales, who is absent from England on an Empire mission.

Having shown you the sites, I think I cannot do better than continue now with pictures showing the progress of certain of the main buildings and portions of the grounds. I will take first of all the Stadium. From the engineering point of view, the only possible site for the Stadium was on top of the hill, as only at that elevation could the excavated bowl be sufficiently drained. The position was also influenced by the necessity of reducing the amount of digging and surplus earth to a minimum, and in the general lay-out the main buildings are exactly calculated so that the necessary excavation into the hill on one side balances the amount of earth required for building up the floors on the lower level.

This picture shows the first excavations of the Stadium, and gives a very good idea of the work that had to be carried out before the Stadium was complete.

Now comes an aerial view of the golf course on which the Exhibition was built, showing the early work on the Stadium in progress.

The next picture is an aerial view of the progress of work on the Stadium, and it clearly shows the surrounding country, consisting of nothing but fields on which the Exhibition was built.

Specialists from Kew Gardens were able to transplant trees, old as they were, and many 40 feet high with a ton or two of soil attached, to different sections of the grounds, where they are flourishing to-day as though they had never known what transplanting was. This is a picture of one of the huge trees being transplanted from the site of the Stadium.

Here is a massive derrick for hoisting steel girders into position.

You will now see the huge amphitheatre, designed to accommodate 125,000 spectators, in course of construction.

Here is a picture of the Grand Stand taking form.

Before, of course, such a building could be used for its intended purpose, the stands and terraces had to be submitted to severe tests, and I now show you the methods followed in carrying out these tests.

This slide shows a load of 300 tons on a section of the stands with a body of men who performed various evolutions such as marking time and jumping in unison.

The picture following gives you some interesting details of the materials used in the construction of the Stadium.

Some critics stated that the Stadium is more like a fortress than a sports-ground. I must confess I am inclined to agree with that view, and without disparaging the architectural beauties of the Stadium, I think the picture shown certainly gives the impression that there is some truth in the suggestion. I would, however, point out that a good deal of this fortress effect results from the alterations which the authorities insisted upon being carried out after the Football Cup Final in 1923, when over double the number of spectators at any previous Cup Final attempted to gain admission. One point regarding the Stadium which has always caused me some amusement is that nearly all its entrances are marked " Exit Only." Before I leave the Stadium I must show you a scene of the opening ceremony performed by His Majesty the King last year, which I think, everybody is agreed was one of the most impressive ceremonies ever held. It is said to be a sign of the times that a considerable proportion of the public are ever seeking a new thrill. To those in search of that experience, I would tender this advice : Do not be absent from the Stadium on May 9th.

We now come to the lake. This view shows the commencement of work on the lake. The ornamental lakes between the Stadium and the main buildings were also determined from their usefulness. It is obvious that when a piece of virgin country is turned into buildings and roads, the rain water falling upon them comes off at a very much greater speed than formerly, and as the entire rain water from the Exhibition buildings has to be finally discharged into the brook at the bottom of the hill, it was necessary to provide a reservoir halfway, in order that flooding should not occur in sudden stress. The rain water from the Stadium and the buildings south of the ornamental lakes discharges into the lakes, which are so arranged that they rise 9″ before they begin to overflow into the rain water cistern which discharges into the brook, and thus the water from any sudden thunderstorm is taken first to the lakes and ultimately into the lower plains. There are, therefore, definite engineering reasons for the Stadium being on the hill, the lake at the foot of the Stadium, and the main buildings on the plain.

You will see here excavation work being carried out on the lake with a close view of the steam navvy performing its function of lifting over half a ton of earth at each " bite."

Finally there are five pictures shewing a large number of visitors enjoying the peacefulness of the completed lakes.

I will now take you to the Main Avenue looking from the lake towards the North-west Entrance. In this picture, showing the commencement of work on the Main Avenue, I would draw your particular attention to the telegraph post in the middle of the picture.

These next pictures show the progress month by month. You will notice the same telegraph post in each picture, but each month more and yet more buildings have grown up around it.

This picture shows you the progress reached on the Main Avenue towards the end of the month of February, two months before the opening. It is appropriate that in accordance with the well-known Wembley weather we should see snow lying on the ground. The picture very faithfully portrays the appearance of the Exhibition at that particular time when I went down to see it, accompanied by the then Colonial Secretary, the Right. Hon. J. H. Thomas. We were all anxious as to the possibility of having the Exhibition ready in time for the opening, and Mr. Thomas, like many others, put the question—" Is this Exhibition going to be opened this year or next year ?" To the uninitiated the picture shown might well warrant such a query, but with the optimistic outlook which has always been one of the chief supports of my life

I replied "Why, this year of course." If I had only had enough vision I might have said "Both." The next two pictures show you the progress on the Main Avenue in the intervening period up to the opening, and you will see the post still in the foreground. I will conclude this section with a view of the Avenue as it appeared on the appointed opening day, and for the first time the post is gone.

We will now turn to the Palaces of Industry and Engineering.

As loads on the floors up to 3 tons were necessary, timber flooring for these buildings was ruled out. Instead, the type of construction adopted was a floor in which concrete slabs were supported by 14-inch brick piers on 8′ 4″ centres in all directions. The brick piers were built before the filling was adopted, and when the filling reached the top of a pier the slab was immediately cast on the filling. This picture shows you the piers prior to the filling up with earth and the laying of the slab floors. The stone slabs having been laid the pillars of the building were built in the form of wooden moulds, the cement being poured in around the steel reinforcing rods. Here is shown this method of construction in progress. The next picture shows the supports of the roof being placed into position. From the last picture to the one you now see a month has elapsed, and you will observe the progress made.

Next I show you the Palace of Engineering as it was on the 11th November, 1923, when completed and handed over by the contractors to the Exhibition Authorities. Here is the Palace of Industry as it appeared during the Exhibition. Now comes the Palace of Engineering at the same time.

In this picture, showing the Power Station, you will notice one of the overhead travelling cranes erected in the Palace of Engineering for the purpose of handling exhibits up to 25 tons. The crane gantries, which are of a length of 900 feet, are broken at intervals by expansion joints, which many people have thought to be cracks through defective workmanship, and observation has shown these expansion joints to be acting most satisfactorily. The cost of the gantries in concrete was half what it would have been in structural steel. Five cranes of this type were erected in the Palace of Engineering and the total tonnage handled during 1924 amounted to 8,000 tons.

Here, I would also mention a fact realised by very few visitors, namely, that in addition to these cranes another method of transporting heavy exhibits is a series of railway tracks directly connected with the main-line railways and running under the floors of both Palaces of Industry and Engineering. These tracks were of tremendous value in bringing heavy exhibits into the Exhibition, and are always available for immediate use merely by raising a wooden floor covering. There are over three miles of these railway tracks always within the Exhibition, open or shut.

I cannot leave these Palaces without referring to the Palace of Arts, situate in the South-west corner of the Palace of Industry.

The admissions to the Palace of Arts proved the great public appreciation of the representative show of the arts of the United Kingdom and of the Dominions which was there staged ; 2,197,920 persons passed through the turnstiles, and of these 1,617,556 visited the Gallery of the Queen's Dolls' House. The Exhibition was able to hand over to the Committee of the Queen's Dolls' House no less a sum than £38,764 5s. 3d. Next to the Dolls' House the most popular feature was the impressive Basilica, with its six side chapels, each of which represented a different note in modern church design, while the great decorative picture of " Service and Sacrifice " by A. K. Lawrence over the main altar marked the vigorous school of decorative painting which England has developed during the last few years.

In the art of the home the Period Rooms, representing 1750, 1815, 1852, 1888 and the present day, were also immensely appreciated by the public.

In turning to the participation of the Dominions and Colonies, I think it will be better if I show you pictures of the magnificent Pavilions which, no doubt, you have all seen yourselves.

We will take them in the order in which they would be visited after leaving the Palace of Arts.

Immediately at the west end of the lake we have the imposing Pavilion of New Zealand, with, at the south end, the Mata-Atua or Maori House, and on the north end the Samoan Fale.

Next to New Zealand we have the striking Pavilion of Malaya, with its striped yellow and white colouring, one of the most picturesque buildings in the Exhibition grounds.

Facing Malaya is the huge Australian Pavilion, which covered an area larger than Olympia.

Continuing down the same side of the lake we have the handsome buildings of Canada, with the two small Pavilions of the Canadian Pacific Railway and Canadian National Railways. The length of these buildings, together with Australia, is equal to the distance from Charing Cross Bridge to Westminster Bridge.

At the far end of the lake we have the Indian Pavilion, built in the 17th century Mogul type. I have no hesitation in saying that the view of the Indian Pavilion, looking down the lake from the far end, is one of the most beautiful which has ever been staged in connexion with any Exhibition.

On the opposite side from India, and facing Canada, is Burma, modelled on the lines of a Burmese Royal House, and surmounted by seven-roofed spires. The Bridge House, a most attractive gem of architecture, reproduces the western gate of the Arakan Pagoda at Mandalay.

The South African exhibits were housed in the replica of an old Dutch House, whilst the provinces of West Africa show for their exhibit a walled city built of red clay, in imitation of one of the ancient Scandinavian castles on the Gold Coast. This, I think you will all agree, is a unique feature of the Exhibition, and adds variety to the exhibits.

Malta recalls the fortresses which Knights of St. John were wont to occupy in the age of chivalry.

East Africa, which included many Colonies, from the Sudan to Zanzibar, was based upon an old African model.

The Bermuda Pavilion was an exact reproduction of " Walsingham," the old home of Tom Moore, the Irish poet.

Lord Stevenson then showed views of Newfoundland, Palestine, Fiji, Ceylon and the West Indies. All the foregoing Pavilions, he continued, are representative of the characteristic architecture of the different countries.

Hong Kong took the unique form of a street of that city. A feature of this street was the silkworm farm, where the life of the silkworm from life to death could be followed. This required continuous attention and a staff was on duty night and day to feed mulberry leaves to the worms every two hours.

We now come to His Majesty's Government Pavilion, which, I am sure you will agree is a most stately building, housing some exceedingly interesting exhibits.

It is worthy of note that the lions in the foreground were constructed of ferro-concrete for the first time.

The illustration following is one of what has often been called " Old London Bridge." It is not really a representation of *the* Old London Bridge, but merely *an* old London Bridge.

The next slide shows how we looked after the children in a Day Nursery.

We are now on the edge of the Amusement Park, and the next few slides will give you some idea of the more exciting amongst the attractions collected to amuse the patrons.

The Never-Stop Railway was a unique feature in the transport of the Exhibition, and is a system which may in future be used to cope with some of our transport difficulties outside Exhibitions. Owing to the many technical difficulties to be overcome, this railway was considerably late in coming into operation, and, as a result, it earned the nickname of the "Never-start Railway."

These little railodok cars were extremely useful for transporting visitors around the grounds. To conclude, I am showing you two aerial views which will give you an idea of the vast expanse of the Exhibition as a whole. These pictures bring back to my mind the story of the boy who, accompanied by his father, stopped to look at an exhibit. His father turned round and said " Come on, come on; we can't wait about." The boy replied, " But father, I want to see this." " Come on," said the father, " that may be; but how do you think we are going to get round this Exhibition if you stop to look at anything ?"

I have endeavoured with the aid of these illustrations to give you some idea of what the building and organising of an Exhibition really means. Of the many difficulties I have not spoken. The building of Wembley was the building of a huge new city. That it was a beautiful city, no one denies. Its beauties are still there ; in point of fact they are enhanced. No one can dimly appreciate the wonderful heritage that has been handed down to the citizens of the Empire who does not visit it, who does not study it, who does not each in his own individual capacity, according to his ability, do what he can to extend his knowledge of what it stands for. Believe me, with a knowledge of Empire fostered by unique opportunities of knowing what it is and what it stands for, and how thin is the thread which holds it together. I cannot conclude without expressing the earnest wish that each of us will pledge ourselves to do our utmost to cement and bind together in a stronger strain the feelings, the sentiment and the give and take necessary to ensure that our great Empire heritage will go on and prosper, not only for the benefit of the citizens of the British Empire, but for the outstanding development of civilisation itself.

DISCUSSION.

THE CHAIRMAN (Sir Charles C. McLeod), remarked that the usual thing to do in opening a discussion on a paper which had been read was to start by criticising it. He was afraid, however, that he was not capable of criticising anything which had been said by Lord Stevenson that afternoon. It was often said that five minutes' conversation was better than reams of correspondence ; and he ventured to think that the three-quarters of an hour which the reading of the paper had occupied that afternoon, together with the slides which had been thrown on the screen, had shown those present the work of two years in a way which could not have been otherwise possible even if one had spent almost every day at the Exhibition.

A great deal was due to Lord Stevenson. Personally he was bold enough to say, because he knew what he was talking about, that if Lord Stevenson had not come on the scene at the time that he had, it would have been very doubtful if there would ever have been an Exhibition ; and he was quite certain that there would never have been the Exhibition which had been presented in 1924.

The Exhibition was going to be opened again on the 9th May this year. Although Lord Stevenson had not said anything about the 1925 Exhibition, he thought the country might look forward to seeing an Exhibition even more complete and brighter than last year's Exhibition.

What the 1924 Exhibition had done in many directions was incalculable. It had brought people from Overseas into contact with their friends and relations in the Motherland, which could not have been done in any other way. He hoped that that feature would be accentuated in the present Exhibition. It was a great disappointment to the authorities that India and Burma were not to be represented this year.

All that was required to make the Exhibition of 1925 a great success were plenty of visitors and fine weather.

LORD ASKWITH, K.C.B., K.C., D.C.L., on behalf of the Council of the Society and those present, thanked Lord Stevenson for his paper. The Royal Society of Arts had always taken a great interest in Exhibitions. It had run the first great Exhibition ever held in this country, namely, the Exhibition of 1851. A year and a half ago, in his Inaugural Address as Chairman of the Council of the Society, he had given a sketch, which could be read in the *Journal*, of Exhibitions up to that period, of what had been achieved by them and of certain mistakes which had been found out in the course of experience. Lord Stevenson that afternoon had gone on with that sketch by showing what Wembley had done. He had shown those great buildings in their making, and the difficulties which had had to be overcome in order to produce the wonderful results which had been presented. Those results in many ways had surpassed all expectations. There had been a vast number of visitors, and the accounts which they had carried to their various homes would, no doubt, lead to still vaster numbers attending the 1925 Exhibition. At any rate, it had had the most wonderful effect in arousing in many minds a knowledge of what the British Empire was, and what it could produce. The object of an Exhibition of such a kind was not for mere amusement, but for instruction and publicity and realisation of facts, and he thought when the accounts of Lord Stevenson's address appeared it would be brought home what the Exhibition had taught and could teach, and what it meant to the Empire at large.

It was a very fortunate and happy decision of the Government again this year to give their support to the Exhibition of 1925. He could assure those present that the 1925 Exhibition would contain a great many novel and interesting features, and that there would be a great deal more there in many directions than there had been in 1924. Those who went this year would not see merely a rehash of the 1924 Exhibition, but they would see many additional novelties.

Attached to the Exhibition was the possibility of becoming a Fellow of the Empire Exhibition, or, if one found that too expensive, one could become an Associate at a fee of 5s., on application to the Fellowship Committee at 16, Grosvenor Gardens, London. Various advantages were given to Fellows and Associates, and from a portion of the funds thus obtained scholarships would be given which would enable people in the Dominions to come to this country and for persons in this country to go to the Dominions. Those scholarships would be distributed from time to time to suitable persons. Therefore, every one who became either a Fellow or an Associate of the Empire Exhibition would be aiding young people to become Empire missionaries between this country and our great Empire, and assisting in the promulgation of that desire which Lord Stevenson had expressed in the last words of his address.

MR. H. A. F. LINDSAY, C.B.E., I.C.S., Indian Trade Commissioner, in endorsing the motion, said as India was not to be represented at the Exhibition this year, it would be audacious on his part to detain the meeting very long. Therefore, the tenor of his remarks would be rather in retrospect than in prospect.

He would like to say first that the commercial results of the 1924 Exhibition, so far as India was concerned, had been excellent. A visitor to the Indian Pavilion would have been struck first with the Arts and Crafts exhibits which had formed so large a proportion of the whole exhibit. Before the Exhibition the art and craft-ware of India had not been so well known as those connected with India would have liked it to be, but he was glad to say that as a result of the Indian exhibit there had been firmly established in this country a taste for Indian art and craft-ware. The retail sales made at the stalls at the Exhibition last year of Indian art and craft-ware had amounted in all to £113,000. Those had been only retail sales, and they had been accompanied in very many instances by extensive orders placed with the manufacturers in India. A further advantage had been that the manufacturers in India had learned the taste in this country and the real requirements and demands which had to be met, and in more than one instance London offices had been opened. All that had resulted from the basis which had been laid last year.

In addition to the arts and crafts there were, of course, the general staple products of India organised in strong associations such as the London Jute Association, the East Indian Cotton Association, the Indian Tea Association, and many others. It was commonly held that the merchant was a gentleman who sat rather above the arena of commerce, and did not have to enter the lists in the same way as the manufacturers, who were always competing with each other and cutting each other's throats. It was thought that a merchant talked largely and thought largely in lakhs of rupees. Sir Charles McLeod would bear him out when he said that the merchant thought very largely in sixteenths or thirty-seconds of a penny, because a thirty-second of a penny might make all the difference between a profit and a loss. The merchants had been chiefly represented by Associations, and India had also benefited by last year's Exhibition from the fact that the Associations represented had gained in knowledge of the requirements of the Home country, and had certainly extended their business. If India was not exhibiting officially in 1925, she yet wished that Exhibition the very heartiest success, and trusted that the Pavilion, which was still standing, would receive plenty of unofficial support.

Professor A. W. Bickerton said he desired to plead with those present to become Fellows or Associates of the Exhibition. He himself had benefited very much by the funds from the 1851 Exhibition, which he had visited and which he remembered perfectly well. He had also visited most of the other Exhibitions, including two Paris Exhibitions, and had spent 40 years in New Zealand. When he was in that country three of his students had obtained scholarships from the 1851 Exhibition, one of those students being Sir Ernest Rutherford, who had spent five years in his laboratory. If it had not been for those scholarships he very much doubted whether Sir Ernest Rutherford would have come to England and done the work which he had done. It was because of the benefit of such scholarships that he pleaded for those present to be Fellows or Associates of the Exhibition.

The vote of thanks was carried unanimously.

Lord Stevenson briefly acknowledged the resolution and the meeting terminated.

GENERAL NOTE.

Steel Industry for Tasmania.—It is reported by the United States Assistant Trade Commissioner at Melbourne that a recently formed company will erect a steel plant near Burnie (Tasmania) to manufacture iron and steel goods for export. Crude ores will be treated in separate smelters to be built adjacent to the steel works. The iron-ore deposits of the Hampshire district, which are to furnish the supply, are said to be among the richest in the world. The large quantities of limestone in this district will supply flux for the furnaces. The plant will be served by the Emu Bay Railway Co., which runs close to the deposits at Hampshire, 20 miles from the port. Negotiations have been entered into with the Tasmanian hydro-electric department to secure power and such coal as will be necessary. It is anticipated that about 40,000 horse-power of electric current will be available for use within 12 months.

MEETINGS OF THE SOCIETY.

Ordinary Meeting.

Wednesday, May 27, at 4.30 p.m.—**The Right Hon. Sir Alfred Mond**, Bt., M.P., "The Unemployment Problem." **Sir Robert Abbott Hadfield**, Bt., D.Sc., F.R.S., will preside.

INDIAN SECTION.

FRIDAY, JUNE 12, at 4.30 p.m.—BRIGADIER-GENERAL SIR PERCY SYKES, K.C.I.E., C.B., C.M.G., "The Heart of Asia and the Roof of the World."

DOMINIONS AND COLONIES SECTION.

THURSDAY, JUNE 18, at 4.30 p.m.—HON. W. G. A. ORMSBY-GORE, M.P., Under Secretary of State for the Colonies, "East Africa."

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

◆

MONDAY, MAY 25..Glass Technology, Society of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 7.30 p.m. (1) Prof. W. E. S. Turner, "The Nature and Constitution of Glass." (2) Prof. G. Tammann, "On Glasses as Supercooled Liquids." (3) Dr. F. Eckert, "Some Remarks on the Constitution of Glass." (4) Dr. A. Q. Tool and Mr. E. E. Hill, "On the Constitution and Density of Glass." (5) Prof. H. Le Chatelier, "On the Viscosity and Allotrophy of Glass."

Chadwick Public Lecture, at the Royal Society of Medicine, 1, Wimpole Street, W. 5.15 p.m. Dr. E. Brumpt, "How to Conduct an Anti-Malarial Campaign."

Philologie, Sciences et Beaux-Arts, Société de, Gray's Inn Hall, Gray's Inn, W.C. 3.30 p.m. Sir D. Plunkett Barton, "Links between Shakespeare and the Inns of Court."

Architectural Association, 34, Bedford Square, W.C. 8 p.m.

Geographical Society, 135, New Bond Street, W. 8.30 p.m. Mr. F. K. Ward, "Through the Gorge of the Tsangpo."

University of London, University College, Gower Street, W.C. 5 p.m. Prof. G. D. Hicks, "Hegel's Æsthetics." (Lecture III.) 5.30 p.m. Prof. A. V. Hill and J. C. Drummond, "Biochemistry." (Lecture IV.)
At King's College, Strand, W.C. 5.15 p.m. Prof. G. H. Macurdy, "Great Macedonian Women." 5.30 p.m. Prof. R. Dyboski, "The New Poland." (Lecture V.)
At the London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. Mr. P. J. N. Baker, "The General Economic Work of the Technical Organs of the League of Nations."
At the London Training College, Southampton Row, W.C. 5.30 p.m. Dr. G. Dyson, "The Evolution of Instrumental Music." (Lecture II.)
At the Imperial College, Royal School of Mines, Prince Consort Road, South Kensington, S.W. 5.15 p.m. Prof. Dr. F. A. F. Went, "Modern Conceptions of Light Stimuli in Plants."
At Gresham College, Basinghall Street, E.C. 6.15 p.m. Mr. A. Compton-Rickett, "Some Writers of Yesterday and To-day—Gilbert Keith Chesterton."

TUESDAY, MAY 26..Glass Technology, Society of, in the Chemistry Theatre, University College, Gower Street, W.C. 2.30 p.m. (1) Sir W. H. Bragg, "The Structure of Quartz and Silica." (2) Mr. V. H. Stott, "The Viscosity of Glass." (3) Dr. G. W. Morey and Dr. N. L. Bowen, "The Melting Relations of the Soda-Lime-Silica Glasses." (4) Dr. A. A. Lebedeff, "Polymorphic Transformations in Glass." (5) Dr. G. W. Morey and Dr. R. W. G. Wyckoff, "X-Ray Studies of Soda-Lime-Silica Glasses."

Glass Painters, British Society of Master, at the Art Workers' Guild, 6, Queen Square, W.C. 5 p.m. Annual General Meeting and Exhibition of Cartoons of Stained Glass.

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. H. C. Brewer, "The Pattern of the Picture."

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. R. Whiddington, "The Passage of Electricity through Vacuum Tubes." (Lecture II.)

University of London, at King's College, Strand, W.C. 5.30 p.m. Rev. J. K. Mozley, "The Doctrine of God." (Lecture I.)
At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Mr. R. F. Young, "The History of the Bohemian Brethren (Unitas Fratum) and their Influence on the Development of Czech Civilisation."
At St. Bartholomew's Hospital Medical College, West Smithfield, E.C. 5 p.m. Dr. H. H. Dale, "Chemical Control of Certain Bodily Functions." (Lecture IV.)

WEDNESDAY, MAY 27..Microscopical Society, 20, Hanover Square, W. 7.30 p.m. (Industrial Applications Section.) Sir John Russell, (*a*) "The Microscope in Soil Microbiology," and (*b*) "The Microscope in Plant Pathology."

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. F. de Zulueta, "William of Drogheda, an English Cantonist and Civilian of the 13th Century."
At King's College, Strand, W.C. 5.30 p.m. Mr. H. W. Steed, "The Emancipation of Roumania and the Russo-Turkish War."
At the London School of Economics and Political Science, Houghton Street, Aldwych, W.C. 5 p.m. Mr. R. A. Smith, "The Metal Ages of Western Europe—The Late Iron Age (Anglo-Saxon)." (Lecture III.)

THURSDAY, MAY 28..Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

China Society, at the School of Oriental Studies, Finsbury Circus, E.C. 5 p.m. Mr. G. Willoughby-Meade, "Ghost and Vampire Tales of China."

Structural Engineers, Institution of, 296, Vauxhall Bridge Road, S.W. 5.45 p.m. Annual General Meeting. 6 p.m. Mr. A. G. Huntley, "Acoustics."

Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. F. O. Bower, "The Natural Classification of Ferns" (Lecture II).

University of London, King's College, Strand, W.C. 6.30 p.m. Dr. O. Vocadlo, "The Czecho-Slovak Republic To-day." (Lecture VI.)

FRIDAY, MAY 29..Chadwick Public Lecture, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 5.15 p.m. Dr. E. Sumpt, "The Prophylaxis of Sleeping Sickness."

Royal Institution, Albemarle Street, W. 9 p.m. Sir Henry Newbolt, "Scenery in the Pastoral Poets."

SATURDAY, MAY 30..Royal Institution, Albemarle Street, W. 3 p.m. Rev. E. M. Walker, "Democracy in the Ancient World."

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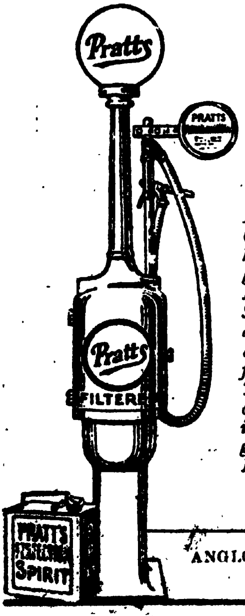

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FRIDAY, MAY 29, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

INDIAN SECTION.

FRIDAY, 22ND MAY, 1925. SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S., in the Chair.

A paper on "The Industrial Progress of the Mysore State" was read by SIR ALFRED CHATTERTON, C.I.E., Assoc.M.Inst.C.E.

The paper and discussion will be published in a subsequent number of the *Journal.*

VISIT TO CROYDON AERODROME.

At the Ordinary Meeting held on May 6th last, when Air Vice-Marshal Sir Sefton Brancker read a paper on "Commercial Aviation," a suggestion was made that Fellows of the Society might like to visit the Aerodrome at Croydon. Sir Sefton Brancker communicated the proposal to the Air Ministry, who have now intimated their readiness to receive a party of twenty Fellows at the Aerodrome on Thursday, June 25th, and a similar party on Friday, June 26th, at 3 p.m.

Fellows of the Society who desire to avail themselves of this invitation are requested to communicate at once with the Secretary of the Royal Society of Arts, John Street, Adelphi, London, W.C. 2. In doing so they should state whether they will be able to attend on either day.

The number of visitors has to be strictly limited so as to permit of those who accept the invitation being shown over the Aerodrome.

Tickets of admission will be issued in the order in which applications are received.

COMPETITION OF INDUSTRIAL DESIGNS.

By kind permission of the Director of the Victoria and Albert Museum, the second Annual Competition under the Society's Scheme for the Improvement of Industrial Designs will be held in the North Court of the Museum. The last date for receiving designs is June 24th.

Applications for entry forms have been received from over 1,000 candidates, as compared with a total of 553 last year.

The Board of Education have signified to the Council their warm approval of the Scheme, and, on the invitation of the Council, they have nominated Mr. Henry Allport, H.M. Inspector of Schools of Art, to serve on the Central Committee.

TWENTY-SECOND ORDINARY MEETING.

WEDNESDAY, MAY 20th, 1925. MR. ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council of the Society, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Binns, Herbert, Keighley, Yorks.
Brinton, Selwyn, M.A., Southwick, Sussex.
Burnham, The Right Hon. Viscount, C.H., London.
Herr, Miss Helena, M.B.E., Chislehurst, Kent.

The following candidates were duly elected Fellows of the Society:—

Langer, Carl, Ph.D., F.C.S., Woolhampton, Berks.
Lawford-Jones, Arthur John, Slough, Bucks.
Leonard, Ernest Arthur Edward, Barking, Essex.
McMurray, J., C.B.E., Teheran, Persia.
Mirchandani, Narain Khanchand, Sheffield.
Pehrson, A.P., Sheffield.
Radford, Henry C., Southampton.

A paper on "William Sturgeon and the Centenary of the Electro-Magnet" was read by PROFESSOR JOHN AMBROSE FLEMING, M.A., D.Sc., F.R.S.

The paper and discussion will be published in a subsequent number of the *Journal.*

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "Modern Colour Problems," by Louis C. Martin, D.Sc., A.R.C.S., D.I.C., F.R.A.S., Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and Technology, have been reprinted from the *Journal*, and the pamphlet (price 2s.) can be obtained from the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures which have been published separately and are still on sale can also be obtained on application.

PROCEEDINGS OF THE SOCIETY.

NINETEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 29TH, 1925.

SIR GEORGE NEWMAN, K.C.B., M.D., D.C.L., Chief Medical Officer, Ministry of Health, in the Chair.

The paper read was :—

THE TREND OF MODERN HYGIENE.

By ANDREW BALFOUR, C.B., C.M.G., M.D., D.P.H., F.R.C.P.E.

The trend of modern hygiene or the modern trend of hygiene—which is the better title ? It is a moot point, but, after due consideration, I decided to employ the former for the following reason.

While one must admit that, almost from the beginning of time, or at least from the beginning of human history, certain general hygienic principles have remained unchanged, and while one must also agree that much of our latter-day hygiene is a reversion to the practice of the Ancients, yet of late years such a remarkable and far-reaching change has come over both the spirit of our dreams and our actual undertakings that we may, with some justice, assert that a new hygiene has been developed, a modern health campaign possessing features which entitle it to be classed as a distinct entity.

Let us consider the argument a little in detail. I have mentioned the Ancients, those remarkable beings who, unaided by scientific appliances, devoid of our elaborate armamentarium, groping, as it were, in the dark, yet succeeded in penetrating into many of Nature's secrets and solving riddles which at one time we fondly imagined had been elucidated by ourselves. As has been pointed out time and again, there has within recent years been a change from the hygiene of environment to that of the individual. This has been hailed as a great step in advance, and yet much of what we regard as new had its counterpart in the days of the Greeks and the Romans.

It would seem that the ancient Greeks were the first to recognise the importance of personal hygiene, to understand that, just as charity should begin at home, it was essential for the individual so to develop and care for his frame that it might be placed in a position to defy the onslaught of disease and to resist decay, both of body and mind.

Mr. C. J. S. Thompson recently wrote an interesting paper on " Medical Gymnastics in Greek and Roman Times." He quotes Galen, who stated that Hippocrates, a great hygienist as well as a great physician, Diokles and

Praxagoras, first appreciated the importance of medical exercises and gymnastics, although, according to Plato, Ikkos of Tarentum, who flourished about 470 B.C., was the actual inventor of the latter.

In all probability, however, those pioneers, the ancient Egyptians, had long before recognised that the body was a machine and required careful attention if it were to perform its functions properly and keep disease at bay. We gather as much from the hygienic code of Moses. It is the fashion nowadays to quote Moses as a sanitarian, and it is interesting to note that this itself is no new thing. A very remarkable and far-seeing British army surgeon, Donald Monro, who lived in the latter part of the eighteenth century, directed the attention of his readers to the instructions issued by the Patriarch.

Presumably, you know your Leviticus and Deuteronomy, so I need not enlarge upon the maxims of Moses; those wise injunctions to the Israelites anent personal cleanliness, the use and abuse of food, the avoidance of infection, care in the disposal of excreta and so forth. Moses, however, was merely heir to the wisdom of the Egyptians, and possibly the Egyptians derived much of their knowledge from earlier civilisations.

Still, despite their perspicuity in many directions, it would seem that the Ancients considered the health and hygiene of the individual rather from the individualistic standpoint. So far as we can tell, they did not lay stress on the importance of the healthy unit in his or her relation to the community. The Greeks prized chiefly beauty and perfection of form. Both in Greek and Roman times much of the hygiene we are considering had a religious basis, and religion has always been more or less individualistic. Hence, possibly, for we must always remember that our knowledge of these remote times is limited, the Egyptian, the Greek and the Roman did not grasp the full significance and value of the mother, the infant and the child to the State, or, at least, did not adopt measures to safeguard them from the malign influences to which, no doubt, they were exposed.

It is possible that the large proportion of infants' and children's graves in the burial places of ancient Nubia and pre-dynastic Egypt may be evidence of such oversight. Professor Elliott Smith agrees that this may be the case and he has also told me that the remarkable paucity of children's remains in dynastic times may indicate that the Egyptians took so little stock of children that they did not think it worth while to accord them sepulture. It would, of course, be a mistake to imagine that the Ancients concentrated on personal hygiene, in certain of its aspects, to the exclusion of public health measures directed to environment. The ruins of the Roman aqueducts are testimony to the contrary and the Greeks, long before the Romans, were masters of sanitary engineering. They had their subterranean aqueducts conforming to the configuration of the ground and knew how to ventilate them by air-shafts. There is some reason to believe that these same Greeks may have recognised that improved health followed swamp reclamation. At any rate, the Minyans carried out remarkable work on Lake Kopais.

It is sad to think how all this knowledge was lost, how all this endeavour passed into the limbo of forgotten things. The Romans brought their hygienic culture to Britain, and, in a climate differing greatly from their own, continued the practice of the bath and devised and executed the hypocaust system of heating to which we are even now returning in the case of certain buildings.

Then came war and turmoil, followed by the blight of the Middle Ages. True, there was a renaissance of learning, but the renaissance of hygiene lagged far behind it, for it was not until Richard Mead thought and wrote that the nation to which he belonged began to gain some real glimmerings of sanitary sense, and it was not until long after his day that it began to evolve a sanitary conscience.

The story has often been told and need not be repeated, but it may be said that, naturally enough, the pioneers, Howard, Pringle, Monro, Lind, Trotter, Shaftesbury, Chadwick, Simon, Southwood Smith, Snow and others, to mention only a few, directed their energies mainly, if not exclusively, to the amelioration of environmental conditions which urgently called for remedy. There were Augean stables to be cleansed, and for a space their inhabitants, asses for the most part, had to be neglected. Moreover, the knowledge we now possess, knowledge of bacteriology, of physiology, of psychology, of bio-chemistry, of eugenics, was not available, so that had there even been time to consider the individual in the midst of the warfare against ignorance, superstition, parsimony, narrow-mindedness and vested interests, the devoted men who led the way could not have dealt with the unit to the best effect. Gradually, however, as order took the place of chaos, as cleanliness replaced dirt, as the work of the laboratory came to be applied to every-day life, as there was more time for thinking and observation, it became evident that, despite all the progress made, there yet remained new worlds to conquer.

While the great campaign had been proceeding, new factors had been introduced into communal life. The population had become largely urban, industrialism had set its seal upon the people, food conditions had changed, the strain and stress of existence had become intensified. Moreover, it began to dawn upon those responsible that there were forces, malign forces, at work which tended to counteract much of the good that had been accomplished and which could no longer be permitted to play havoc, through the individual, with the health and prosperity of the State.

Thus was born that modern hygiene which, maintaining and amplifying the principles and practice of sanitation, cast its net wider and enfolded in its meshes, not only the adult, but the infant and the child, not only the infant but the embryo; which reached out a helping hand to the healthy as well as to the diseased, which strove and still strives to get at the root of things and to nip infection in the bud.

The outlook has changed and, while it is impossible to deal here with all the new vistas which have opened up, all the new avenues which are being explored and all the new developments which are taking place, there are some which will repay attention, if only as a preliminary consideration pending some remarks as to how the ideal which has been set may best be attained. That we are a very long way from that ideal is made startlingly evident from the army recruiting figures recently announced. No less than 49,245 would-be soldiers, or five out of every eight applying, were rejected during 1924 on account of mental or physical defects. Even if some of these rejections are due to a higher standard being now required, the figures give us furiously to think.

The most important item in the public health campaign is beyond all doubt education; not so much education of the medical student, the medical man, the dental surgeon, the veterinarian, or the sanitary inspector, as education of the lay public. It sounds simple, but in reality is beset with many difficulties, and perhaps the chief obstacle which lies in the way is the innate selfishness which seems to pervade such a large section of the community. In some this selfishness is not far removed from the stigma of criminality, but in the vast majority it is more or less unconscious, and is the result of thoughtlessness, ignorance, preoccupation, for many have to fight for bare existence, or a false conception of values.

I am inclined to think that a great many good folk who try to follow the golden rule somehow never think of it as applying in matters hygienic. It may be, it doubtless is, the case that, like Gallio, they care for none of these things, partly because long ago it was necessary to entrust certain agencies with the duty of carrying out public health measures and the English public, easy-going and having paid, not illiberally, to get the job done, took little more interest in it. Perhaps also there was, in earlier days, a tendency on the part of those who controlled health matters towards the priestly cult. It was perhaps natural, for they had to deal with a lamentably ignorant populace, and so may, to some extent, have followed the custom of antiquity, when the religious orders, hankering after power or distrustful of the people, amassed and jealously guarded the knowledge which meant so much to mankind. It must be remembered, however, that sufficient time has not yet elapsed for the effects of the new hygiene to be generally apparent. Striking results have been obtained and are being obtained, but it will take at least a generation before any great and universal effect will be visible, and our modern activities have not been in full swing for five and twenty years.

A gratifying feature of the educational campaign is the number of voluntary agencies striving to impart knowledge and to popularise scientific endeavour as applied to the public health. No less than twenty-three of these embassies of health, as perhaps we may call them, all operating from London, are listed by Sir George Newman in his important memorandum on Public Education in Health, and there are others scattered about the country. They are concerned with various lines of activity and, doubtless, accomplish much good work, but the tendency nowadays is to make Health Departments responsible for the dissemination of information. This is a duty which, of course, has been shouldered by the Ministry of Health in this country, and which has also been undertaken by the health departments of various municipalities, as witness the legends which now appear on lamp posts and the posters and pamphlets which warn and guide the citizen. Of special interest are the recent developments in Bermondsey, where great activity has been displayed in several directions.

The system has been very highly developed in certain parts of the United States, but that there is considerable need for expansion, or perhaps one should say improvement, there, is shown in a recent paper by Dr. Cooper, Assistant Secretary of the North Carolina State Board of Health. He marshals the reasons why public health education is a duty of health departments and indicates how the latter may function as educationalists. Conditions in America differ in many respects from those obtaining here, but in the discussion on Dr. Cooper's paper rather an interesting point was raised. Dr. Rankin, the energetic State Health Officer of Raleigh, speaking of Press work, pointed out the need for brains. He stated: "If you take the amount of money you spend on paper and the mechanics of public health education and compare that with the small amount of money we are spending on the brains that go on the paper, you will see that the health departments follow practices that no business concern would endorse."

This does not apply in the same degree to this country, and yet, taking newspaper campaigns, there can be no doubt that the public health matter appearing in the daily press might often be rendered more attractive and more accurate. My own feeling is that there should be a closer co-operation between health authorities and the Press and that the latter should be supplied with authoritative, well-written and up-to-date articles. The trouble now is that if a medical man sends a contribution to a newspaper under his own name he is apt to be classed as an advertiser. Opportunity, therefore, should be afforded the skilled hygienist to deliver his message under the ægis of a health department.

Here is what Dr. Dale, of the State Medical Department, Western Australia, says on the subject in a short but illuminating paper on " Publicity " in Public Health Administration, which appeared in that admirable publication " Health," the journal of the Commonwealth Department of Health :—

> " The publicity work of a health authority can be carried out in many ways. One of the most valuable is by means of the publication of articles in the Press, both daily and periodical. Even if considerable expense be entailed, it can be justified, and a close understanding with those in control of these organs is the first desideratum. Pamphleteering and the issue of special literature in various forms may also be effectively employed.
>
> " In order that the activities of their officers in this direction may receive

the necessary encouragement, health authorities must come to realise that when they are engaged upon the preparation of matter for publication, for lectures, etc., or in the study of professional and technical literature, they are 'at work,' and such work is as remunerative and deserving of remuneration as any of their other duties."

Dr. Daley, formerly Medical Officer of Health for Blackburn, pleads, with good reason, for the creation of Publicity Committees, which should contain members of the Health Committees of Councils. On the Publicity or Health Education Committee, he would, I note, place representatives of a great many interests. "Too many cooks may spoil the broth," yet I would venture to add to his list, which, amongst others, includes the Press, Cinema Proprietors, and the Chief Constable, the local Veterinarian.

In this country we do not yet fully realise the importance of veterinary science in its relation to the public health. It is, I think, significant that the recently-appointed Assistant to the Director of Helminthology at the London School of Hygiene and Tropical Medicine is a well-qualified veterinarian, and I anticipate much good from this association. I feel that a whole lecture could be devoted to what might be called the Veterinary side of Public Health. Well, the Press can do a great deal if rightly guided, and yet it will be long before the citizen fully realises his duties towards the community, his duty to himself or the elysium which awaits him if he will only take these responsibilities seriously.

Seldom have I seen the case better put than by Dr. Drury in his address at the Nineteenth South African Medical Congress. Speaking about the public health, he says:—

> "Suppose that, as a community, we determine to guard ourselves against these prolific, lowly organisms which, taking advantage of air, food, water, and insect parasites, live an unnatural life at our expense, so that there was an end to the preventable fevers called enteric, typhus, Malta, and the rest; an end to hydatid disease, bilharziosis, malaria and sleeping sickness; an end to venereal disease, to leprosy and perhaps to tuberculosis. Suppose, further, that building regulations abolished slums, and made our houses sun-traps or cool chambers according to season, how much preventable disease and disorder would cease. To reach such a state, we must learn to think so naturally, as members of a community, that we shall feel at least as much self-reproach in publishing rotten books or spreading infection in a school, in spoiling a landscape with refuse, or wasting water, in overworking servants or driving with an open exhaust, as we do now in eating peas with a knife or dropping aitches."

Turning to the personal aspect, he cites what man must do to be saved physically and mentally, and continues:—"Grant these further suppositions, none of them impracticable, and in three generations our race might rival the classical inhabitants of that most favoured land of Greece. It sounds easy, but to overcome our personal sloth, and to stir us to a spasm of emulation, it needs that a modern prophet clothe himself in a leopard skin, display a 17-inch expansion of chest, and dispense elementary physiological knowledge in return for cash in advance."

The lack of public interest in health matters is evidenced by the proposal made to disguise cinematograph films of educational value in hygiene. If their real nature is declared, the public fight shy of them, even if they be attractive and amusing.

I remember visiting one of these cinema premises in Wardour Street to see a " Swat the Fly " film put through for trial. The operator showed it me politely, but obviously with some contempt, although he was an American, and Americans, generally speaking, take more notice of public health questions than do people in this country.

" This kind of film," said he to me, when it came to an end, " don't cut any kind of ice; we got no sale for them. Now, sir, let me show you something with 'pep' in it," and he proceeded to demonstrate an absurd but comical film of a man who would not insure his life until certain amazing war experiences, passed through in a dream, induced him to change his mind.

The question of life insurance brings to mind quite another kind of education and a new trend of hygiene. Human nature being what it is, a considerable section of mankind is more influenced by what we may call financial education than by any other means. Demonstrate material monetary benefits resulting from hygienic measures and you may carry the day. Life insurance companies have of late years realised this cardinal fact and some of them now operate, as Dr. Otto May has pointed out, in three ways. At least, certain of the American companies do. Here we are more conservative and cautious, while, of course, National Health Insurance has been established in this country and, to some extent, proceeds along the lines which a company like the Metropolitan Life Assurance of New York has followed. Some of the advisory medical officers to British companies, including Dr. May himself, are not yet convinced of the utility of all the American undertakings. These latter are of a tripartite nature and may be listed shortly as propaganda, the endowment of research and individual case treatment. The last named connotes periodical medical examination of policy holders.

The first two are beyond criticism, but the success of the third is imperilled, partly because it is difficult and expensive to establish a really effective diagnostic service and partly because a lack of interest is apparent amongst policy holders. They submit to a first examination impressed, perhaps, by its novelty, but few present themselves for a second and still fewer for subsequent overhauls. Hence, Dr. May and others believe that in this country Insurance Companies had better confine themselves to supporting voluntary health organisations. It would seem that the time is not yet ripe for the above-mentioned development, although it was suggested in England by

Dr. Dobell as long ago as 1870. There is always a pioneer in matters hygienic, a John the Baptist, and in this question of periodic physical examinations Dobell played a part like that filled by Robson in connexion with the control of venereal diseases. Both were like voices crying in the wilderness.

The insurance companies, swayed by financial considerations, led the way, chiefly through their life extension institutes, but the tendency now is to entrust the work of periodical examination to the family physician. Indeed, the American Medical Association is devising methods to this end, and its Bureau of Health and Public Instruction has prepared a standard blank indicating how such examinations should be conducted.

That such a consummation is highly desirable, that it may have far-reaching results and that it should react on the health of the community, is emphasised in a typical American manner by Dr. John Dill Robertson, of Chicago. He does not hesitate to charge the general practitioner with criminal negligence, hoping that his message will prove so irritating that it will stimulate him to a sense of his responsibilities as a guardian of the public health in his own special direction. According to Robertson, who, of course, merely voices in rather a strident tone the views of others, the true function of the private practitioner is not to cure the sick, but so to advise his patients, or, rather, his clients, that they will remain in good health. Here is his message, which certainly has "pep" in it:—

> "Go to your office to-morrow morning, take down your record and find how many people there are for whom you are the family physician. Take those that have been to your office during the past year; write them a letter; tell them you would like to have them drop into your office; that you would like to talk to them . . . . and sell them the idea of health. . . . Tell them that they should have a thorough physical examination . . . . and when you make this examination, make an examination that will impress them, not a careless one, not a stick-out-your-tongue-let-me-feel-your-pulse examination, but an examination they will talk about . . . . an examination from head to foot . . . and when you get all through with your instructions and with your examination, then you are ready to have them sign up with you for a continual, continuous audit of their physical banking account."

After all, this is to all intents and purposes the scheme devised by those very wise Ancients I have not mentioned, the Chinese, who paid the doctor so long as his patients were well, but expected free attendance from him when they were ill. Dr. Robertson, however, would seem to have improved on the Chinese method, at least from the doctor's point of view, if there is any truth in his concluding prophecy:—"When you have 600 patients (the number of individuals in Chicago to each physician) signed up, you will be amazed at the fact that your income has doubled and trebled in the course of a year."

I have cited Dr. John Dill Robertson because he has an arresting way of putting things and because his reference to dollars, even if they are only doctors' dollars, should appeal, but away back in 1907 the same argument was advanced more quietly, less picturesquely, but as forcibly by Dr. John McVail in a memorandum accompanying his report on Poor Law Medical Relief in England and Wales. In a recent address he developed his theme and indicated seven directions in which the family physician might be of service as a valuable ally of the Medical Officer of Health.

I cannot here quote him in full, but he deals with the doctor as a historian, an enquirer into family history, and as an observer and checker of tendencies towards general disease. Let it be noted that amongst the diseases mentioned figure obesity and alcoholism. He envisages the physician as a health guardian of the child, a watchful attendant both of mind and body, a corrector and remover of defects, an adviser to the parents. He traces the extension of this medical care to the youth and the maiden, when the practitioner should guide as to work and athletics and be upon the *qui vive* to remedy faulty tendencies of all kinds at the threshold of adult life. He pictures him as the friend and confidant of the woman, saving her from the special troubles besetting her sex and watching the adult man, to see that he does not develop some trade disease, strain his heart or damage his respiratory organs. In addition, he speaks of general examinations like those for which Dr. Robertson pleads, and he figures the doctor as a prop for old age trying to ward off apoplexy and stay the morbid processes which too often make the evening of life a tragic misery.

Dr. McVail is careful to point out that the doctor can only assume such a rôle with the consent of the individual—the adult for himself, the parent for the children.

A specific application of this fine ideal, an ideal which, as we will see, requires certain developments or ever it can come to maturity, is seen in the investigation of "golf hazards" by Dr. Lieb, who, startled by the occurrence of sudden deaths upon the links, collected data which he incorporated in a paper published by the "New York State Journal of Medicine." Dr. Lieb found that in every case organic disease was present and that the golfing was only an accessory factor. The important point, however, is that, had those who perished undergone periodical physical examinations and had ordered their lives in accordance with the findings, they need not have died.

Just as after 40 diet should be modified for each decade of life, so should exercise be regulated at, and after, 50, the meridian. One has not time to enter into Dr. Lieb's details, but he divides golfers who are of medical interest into two classes, the neurological, highly-strung and petulant, and the cardiological who possess weak hearts, high blood pressure and other circulatory defects. Golf, as no doubt many of you are aware, can be a very annoying game. It certainly makes nervous people more nervous. It also makes peppery people more peppery. The irritability induced by golf has long been a godsend to the comic papers. We all know, by repute, at least, the choleric, retired colonel with the red face, the strong language and the broken-shafted driver.

His face is redder and his language stronger if he happens to be playing for a wager, and Dr. Lieb denounces playing for stakes as dangerous both to the nervous and the choleric players who have passed the meridian and are not perfectly sound. Indeed, he lays down certain health rules for veteran golfers, amongst which I note only avoidance of playing golf with one's wife! Nothing is said about another man's wife acting as partner or opponent. Presumably this is less dangerous, even though in some cases the heart may be affected!

Now while, presumably, the majority of medical men at the present time could be trusted to give a sound opinion on the middle-aged golfer, it is by no means so certain that they could adequately fulfil the duties listed by Dr. McVail. They have been reared, be it remembered, in an atmosphere of curative medicine and they have not been trained to look for the beginnings of disease.

Of course, amongst them there may be a few Sir James Mackenzies with the seeing eye and the understanding heart, but, taken as a whole, the general practitioner is a patcher, not a preventer.

That is not his fault. In the past his training has been defective.

For one thing, he has struggled through a series of more or less water-tight compartments. There has been little linking up of his early scientific knowledge with his later medical and surgical studies and, if he is to act effectively, his medicine and surgery must be leavened with a leaven wherein physics, chemistry, biology, anatomy and physiology are combined as ingredients together with sympathy and common sense. For another, the doctor, as a student, has been so crammed that too often one mass of ill-digested facts has, throughout the curriculum, crowded out another in process of assimilation and the only wonder is that he has emerged sane and sound and with a modicum of useful knowledge.

For yet another, the preventive aspects of his life's work have not been explained to him and the vast possibilities which lie before him are too often as a sealed book.

Now all this is changing. The beginnings of that change are recounted in the masterly treatise by our distinguished Chairman, his memorandum entitled " Recent Advances in Medical Education in England," or, as he might have written, " Great Britain," for he cites Scotland again and again and the old Alma Mater which I had the honour to share with him.

Sir George Newman and others have remembered what happens when the blind have blind leaders, and by degrees a new type of doctor should be evolved, who, it is to be hoped, will combine the acumen of the old clinical observer with the broad outlook of the sane scientist.

In his brochure, for it is more than a memorandum, Sir George paints with a broad brush and deals to some extent with the training in public health. He returns to the charge in his paper on " The Permeation of the Medical Curriculum with the Preventive Idea." Therein he does give certain specific indications of how this desideratum can be attained, but the whole question has still to be thought out in detail and in many cases the professors and lecturers have themselves to be inculcated in the underlying principles.

We seem to be lagging a little behind the United States in this particular, for there Professor Leathers has recently been appointed to a chair, in Vanderbilt University, Nashville, Tennessee, which will be concerned with this permeation work. It is a hopeful development and the results will be awaited with interest.

I have mentioned food, and one of the most significant happenings in the modern health campaign is the attention paid, not only to dietetics, but to food preservatives and to the handling of food stuffs. The layman, I fear, must be a little bewildered by all that is said and written about diet. Screed succeeds screed on vitamins. Here an authority thunders against butchers' meat and starchy foods, there an oracle condemns milk for adults. We read of human cesspools. We are told that our faulty food habits explain the increase of cancer.

At times one wonders how the human race has managed to survive at all, and exclaims with Pontius Pilate, " What is Truth ? " And yet we are progressing, for we are beginning to understand the relation of diet to endocrine secretion and we are correcting errors into which we have drifted through non-adaptation to our complex surroundings, through failure to understand that what the primitive man can do with impunity, the civilised man, or at least the town dweller, does at his peril.

The truth really lies in moderation, for, in a phrase I once coined and which perhaps will bear repetition, it is still the case that many folk by their copious libations wash themselves into graves which they have dug with their own teeth. Copious libations do not signify wholly, or even mainly, the imbibition of alcoholic beverages, for a vast deal of digestive trouble is brought about by excess in tea and coffee drinking and by the swilling of liquid, frequently in effervescing form, during meals. Most of us after middle age eat far more than we require. War experience should have taught us a salutary lesson, but, like other lessons, it has been forgotten.

I am inclined to think that eventually the chief value of the scientific tirade on foods and feeding will be found to lie in the fact that it will teach some sections of the most important class of the community—the workers—how to live cheaply as well as healthily, how to get the best food value for money spent. This in itself is a great matter, for the waste at present is enormous. Remember, however, there are many poor housewives who, on the practical side, could give the scientist points.

The tendency to take stock of the evils resulting from the addition of certain preservatives to food is undoubtedly beneficial from several points of view, while, at long last, we are beginning to realise that we are a dirty nation in many matters concerned with food-handling. Control in this direction is badly needed, but it is easy to exaggerate the actual risks to life and health from the mal-practices which we see all around us. They exist in some measure and are serious in the case of milk, but, generally speaking, they are not so direful as some would have us think. Otherwise it would be a poor look-out for most of us. A very sound paper on this subject, a paper dealing with the practical value of the examination of food handlers in the army was recently contributed by Major Parsons, of the United States Army Medcial Corps, and will be found in *The Military Surgeon* for last January.

Apart from the question of infection, however, it is most desirable from an æsthetic and educative standpoint that food, even food which is to be cooked, should be handled and purveyed in a cleanly fashion. Dirt begets dirt, and dirt and disease have ever been close companions. It must be apparent that everywhere education is the prime factor and education connotes co-operation.

We have seen how voluntary organisations co-operate with official agencies, how health authorities should co-operate with the lay Press, how insurance companies try to co-operate with their policy holders, how the doctor must co-operate with his clients, and we might also have considered the co-operation of the employer with the employed, but perhaps the most significant trend in modern hygiene is that international co-operation which has sprung into being since men ceased slaughtering each other. True, there was international co-operation prior to the Great War—quarantines an old story—but there has never previously been a union of peoples on a large scale, not solely for the purpose of safeguarding themselves from the ravages of disease, but with the avowed intention of stamping out disease, wherever found, and of spreading light and learning.

It is a fine conception and is seen in its highest development at Geneva, where the Health Section of the League of Nations is engaged upon its beneficent and widespread work, and in the foreign operations of the International Health Board of the Rockefeller Foundation, for these, though of American origin, depend upon collaboration with other nations.

Professor Madsen, of Copenhagen, has recently described the health organisation of the League of Nations, and lists its chief activities as follows:—

1. Measures for the control of epidemics.
2. The standardisation of certain laboratory products and procedures.
3. Co-operation with other League of Nations organisations in matters that involve medical or public health questions.
4. Promotion and improvement of public health work by the so-called interchanges of health officers between different countries, and by technical advice to various governments.
5. The collection and dissemination of epidemiologic information, including the co-ordination and improvement of vital statistics for international use, and epidemiologic research.

6. Miscellaneous.

Here is a remarkable programme, and still more remarkable are the ways in which it has been carried into effect and the results already achieved.

As for the International Health Board, it has spread its campaigns all over the world and its operations are as diverse as they are valuable. It pursues the hookworm in many territories, it wars against the mosquito, both the malaria carrier and the yellow-fever carrier. Indeed, as regards yellow fever, it has succeeded in well-nigh obliterating that disease from the New World and is now, like Alexander, seeking another world to conquer, and finding it in the French and British possessions on the African West Coast. It has helped the French to fight tuberculosis, it has aided in the medical education of the Chinese, it has given huge grants to many countries, including our own, for the development of public health teaching and research; it is, in short, a kind of fairy godmother to the nations. A less pleasing simile is that of a universal milch cow and yet it is apposite, for in a way it supplies the milk of human kindness as well as the sinews of war. Now milk is a food for babes, and while it is right and fitting that the younger and struggling nations should benefit by the nourishment so generously distilled from the American udders, and while in certain directions the older, though none the less struggling, peoples, impoverished by the World War, should have their share, for the pabulum is intended for the healing of the nations, yet I confess to some misgivings where the British Empire is concerned. That Empire has good reason to be grateful, but I sometimes think it tends to forget its own responsibilities. True, it has done, and is doing, a great deal, but, as we know, doles, as affecting the character of the recipient, are not always unmixed blessings, and we should see to it that we take our full share in this welfare work.

There is much to be learned from international co-operation, for, after all, the British Empire is a congeries of nations and, apart from any other consideration, anything which serves to bind them more closely in bonds of amity is not only desirable but essential. Surely health considerations should be as potent a tie as financial links! At any rate, they are less mundane and more altruistic. Taking, for a moment, one minor aspect of the question, consider what is done in Holland. There a society called "Tokuni" exists for the purpose of taking care of children whose parents are serving in the Dutch East or West Indies. It is said to be an excellent organisation, and it certainly might usefully have its counterpart in this country.

The British Empire owns nearly one-quarter of the earth, has a white population of over 60,000,000 and a native races population of 400,000,000.

Is this not good enough to make a start upon? It is true that the great self-governing Dominions can be left to look after their own public health affairs—in some ways, perhaps, they manage them better than we do ours—but from an Imperial standpoint it would be well if they were in closer connexion with the Mother Country. There is much they can yet learn from England, there is much that England can learn from them, and some of them, like

Canada, Australia and New Zealand, with all their loyalty and traditions, are tending to drift away in matters hygienic. Of course, it is difficult to keep in touch, but the new London School of Hygiene, when it comes into being, should be able to act as a co-ordinating centre. That School, however, is also a School of Tropical Medicine and Hygiene, and its tropical division plays a not unimportant part, as did Manson's old School, in maintaining relations with our tropical possessions.

It is hoped to develop this aspect of its work and already it is collaborating with the enlightened government of Southern Rhodesia in an effort to determine the precise etiology and pathology of blackwater fever, that enemy of the white settler, that foe to the opening up of the great chain of Central African tablelands which may yet replace India as the brightest jewel in the British crown.

But much more is required than isolated endeavour. As a nation we are not yet fully alive to the needs of our tropical colonies from the health point of view. Things, no doubt, are very much better than they were, at least in certain territories, but there is a lamentable lack of sympathetic and scientific co-operation. How can it be otherwise when there is no properly constituted Colonial Medical Service, when there is no official staff of hygienic advisers, constantly coming and going as there should be? Twenty-five years have passed since they were first suggested, and we are still thinking about them.

This and many other necessary developments have been set forth, have been discussed, have even been fought over—and then relegated to obscurity.

We do not deserve to own some parts of our possessions, for at the present moment, from a hygienic standpoint, they are a disgrace to the British flag.

I have no hesitation in saying that the Americans are justified in the feelings with which they view most of the British West Indies and that the Dutch are more than justified in looking upon some of our hygienic efforts in the Far East with a kind of pitying contempt.

Is this a fitting position for the Empire which bred a Simon, a Chadwick, a Patrick Manson?

Let us not underestimate the difficulties, let us not overlook how much has been accomplished, above all, let us take into consideration what is now being done and be thankful that there is much to our credit, but, at the same time, as we cannot now lead in the co-operation movement, let us imitate it and improve upon it within the confines of the Empire. Is it not significant that on the other side of the Atlantic a Pan-American Sanitary Code has been formulated, to which no less than eighteen nations are now adherents?

I have spoken of difficulties. They abound. For example, if the education of the hard-pressed populace at home is no easy matter, how infinitely less easy is it in the case of primitive and superstitious races. Here is a storysent me the other day by Dr. Kirk, the medical officer of health, Port Louis, Mauritius.

He visited a house for the purpose of rat-proofing it, plague being one of our problems in the old Ile de France, a legacy, by the way, of inefficiency and ignorance.

The guardian of the dwelling was a Hindu woman, who refused him admittance; she explained that she had just purified the place and did not wish him to defile it by entering it with boots on his feet. Looking through the little window he saw a table, on which were set various articles, amongst them a pair of bananas, one of which was pierced by a silver skewer. The woman told him that her little boy had been very sick, and that she had vowed if he recovered to make a pilgrimage to a certain shrine with the skewer through her tongue. The child had got better and she was preparing to fulfil her vow. In addition to having the skewer through her tongue, she had to bind up her jaw to prevent her from speaking while on the pilgrimage, and the journey had to be done on a fasting stomach. It is pitiful, and yet there is hope in the tale, for it reveals a great love of offspring, an honourable fulfilment of a vow, and an implicit faith.

The conditions in a country like India are such that I sometimes think it would be well if the practice of hygiene there and in some other lands assumed the aspect of religious exercises. There are many forms of worship inferior to that of the goddess Hygeia, and if only the devotions could be adapted to the mentality and habits of the people, I believe more benefit would accrue than from all the efforts now made. For one thing, these efforts are of very little use until some progress has been made in Western civilisation, and it sometimes seems almost impossible for this exotic to make any headway amongst the masses. These, however, are easily swayed by an appeal to what, for want of a better term, we may call their spiritual side. Such a movement would, of course, meet with opposition from various sources and could only be carried out by those thoroughly familiar with native customs and beliefs, but it is worth thinking about and might serve as a stepping-stone to higher and better things. All education in hygiene must, in the long run, aim at carrying the people with you. The mailed fist is useful now and then, but one cannot force folk to become permanent devotees of hygiene. It is a matter of persuasion, and a kind of religious persuasion, free of dogma and suited to their needs, might work wonders.

In Africa the case is rather different, and at the present time a great effort is being made to educate the African along sound lines. The trend is towards creating native hygienists who will be able to aid in the sanitary salvation of the Dark Continent. I have no doubt, from what I have seen, that this is capable of accomplishment, though it will take time and money.

What the Americans call " Visual Education " is badly needed, and whether this be accomplished by the cinematograph, by diagrams and models in the schools, or by the establishment of graphic museums, care should be taken that it is not neglected in any scheme for native training. Lastly, both at home and abroad, stress should be laid on the financial aspect of public health work, and the ultimate aim of the hygienist should be clearly and definitely stated. The monetary value of sanitary endeavour is a very tangible thing, and statistics are now available regarding many lines of health work which are most impressive and should convince all save the cranks and the wilfully ignorant. Thus, taking industry, which is so closely related to finance, we know, beyond all manner of doubt, that attention to mental hygiene in factories and workshops promotes harmony and leads directly to a larger output.

In addition, especially in some of our colonies, where money is woefully lacking, stock should be taken of the situation, for funds are frequently expended not to the best advantage, and a careful re-allocation might often provide for pressing sanitary needs. To cite one example, I read the other day of money spent on the establishment and upkeep of a library which scarcely anyone uses in an island where the health conditions are deplorable.

As regards our ultimate aim, it must be pointed out that there is no intention of saving and bolstering up weaklings merely on the chance that here and there a genius will emerge, whose presence will be of infinite value to the world.

"Quo vadis?" is a question not infrequently asked, and not always satisfactorily answered. Yet data are available which prove that the trend of modern hygiene is not the expression of a blind force.

To take only one point. It is doubtless true that Nature's law is the survival of the fittest. Well and good, but all should have an equal chance. There is no sound evidence showing an inherited resistance to disease, and hence we are justified in striving to lessen infant mortality by every means in our power, especially as we know that the saving of infant lives is not followed by an increase, but by a marked decrease, in the mortality amongst children and young adults, our greatest assets.

More difficult to answer is the argument that the work of the hygienist will eventually result in over-population.

It may be so, but we cannot pierce the future, and anyhow this old world of ours has a way of settling its own problems irrespective of puny man. There is a power, a divinity if you will, which shapes our ends and determines the larger issues. In any case, we need not greatly worry.

Professor Penck, a distinguished German geographer, by laborious calculations, has found that, though some countries are over-populated, both relatively and absolutely, yet the earth as a whole contains only one-fifth of the population it could actually support. Even if the present rate of increase continues, which is doubtful, it will take nearly 300 years before the maximal population will be reached. Long ere that time, there will have to be readjustment, but increased knowledge is making that readjustment possible.

Hence, for many years to come, we can labour in faith and hope. As Penck says, "There is no compelling necessity as yet to break with the traditions of the past, but the time will come if the population of the earth continues to increase."

Ravenel expresses the same idea in different words, contrasting the brutality of biological facts with the humanitarian quality of sociological facts, but, though it is true that we have to consider succeeding generations, our vision is limited and our duty is to proceed according to our lights and alleviate and abolish the evils which lie ready to our hand.

A hopeful sign is that there is much enthusiasm and no little idealism in public health circles, and, so long as these are well regulated, they cannot fail of their effect. Yet it is wise to bear ever in mind the dictum of Rienzi and the wisdom of Adam Smith.

Rienzi wrote: " The prudent man may direct a state, but it is the enthusiast who regenerates it or ruins," while Adam Smith, in his "Wealth of Nations," before the dawn of the so-called scientific era, declared " Science is the great antidote to the poison of enthusiasm and superstition."

DISCUSSION.

THE CHAIRMAN, in opening the discussion, said the audience would agree with him when he said that the authorities of the Rockefeller School of Hygiene had chosen a catholic minded man for their director.

Dealing with the paper, he was not disposed himself to take a very depressing view of the figures which Dr. Balfour had quoted about recruits. He thought, perhaps, too much attention and emphasis had been given to those figures, which were exceptional, partly because of an alteration in the standard of examination and partly because of a variety of social circumstances which had attracted to the recruiting office a group of citizens who would not in ordinary times and under ordinary circumstances find their way there. The fact remained, however, that the ideal or the goal had not been anything like reached; but there was much in the way of encouragement.

The three points which had impressed him most in the paper were, in the first place, the trend of imperialism and internationalism in preventive medicine and public health—and a very valuable characteristic of our time it was. He dared say, in long years to come, men would look back to the present as a time when the foundations had been laid for the control of the tropics of the world by the white man. It would prove to have been one of those great age-long changes which few men ever lived to see to their destiny. There had been times in the history of the world when disease had altered the destiny of nations dramatically. Possibly it was doing so to-day, less dramatically but no less surely; and the present generation lived in a time truly described as the golden age of preventive medicine so far in the history of the world. We had seen, partly owing to the enormous advance of inter-communication between nations and races, by the use of a common language more and more over the world, by a vast development of transit and transport, by the powerful agency of the Press in all lands, an internationalism—something larger than a British imperialism—of public health, very sound, very good, and pregnant with great changes to the future benefit of the world. For if the tropics, by the discovery of new knowledge with regard to tropical diseases, could be controlled and inhabited by the white races, there would be seen, not a development of Empire perhaps, but an enormous development of man's control of Nature and of himself, and, he felt sure, a further stage in his higher evolution. So that the first thing with which Dr. Balfour's paper had impressed him was the large sweep, to which it was well that their minds should be drawn, which had quickly resulted from the quite new discoveries with regard to the causes and prevention of the great tropical diseases which were prevalent in certain regions of the earth.

In the second place, Dr. Balfour's reference to the differences which had taken place in the older *régime* in England and the newer would be noticed. Seventy or more years ago, when Sir John Simon was laying down the foundations upon which it was his followers' lot and privilege to build, he drew attention, quite rightly, to the great environment problems. If one looked back to those classic reports of his, and of some of his immediate followers, one would find that they dealt with the environment of man—housing, water supply, sewage, food supply and so on. If one looked at the current records of the Medical Officers of Health throughout the country one would find that their reports dealt more and more with what had quite properly been called by Dr. Balfour the personal or communal aspect of public health. That was not because the environment was unimportant or less important now than in past days; it was because in a large measure the environment pure and simple, as in most civilised nations, had been largely met and the communal services in our own country, and in America and Germany particularly, had shown not only great development during the last half century, but were now being surpassed in some measure, in those three countries at least, by a development of personal hygiene. Now we thought about tuberculosis and venereal disease and cancer, whereas Sir John Simon had to think about cholera. Now we thought about maternity and child welfare, and put those subjects in the front rank of our policy. We thought also of that great British scheme of insurance, full of hope and of sound work, and truly constructed. He was not by any means one of those people who thought that an insurance system of health was a State error. On the contrary he thooght year by year it was becoming stronger not only in its claims but in its fruits. It was very interesting that, on the day when Dr. Balfour was reading his paper, the British people were reading in their newspapers that some of the principles of hygiene, of vital statistics, were finding their way into a British Budget as they had perhaps never done before. They knew the name of the Minister who had first introduced health insurance into a British Budget, and it must be some satisfaction to him that day to see further constructive work being done in that direction. It was but an example, but it was an interesting coincidence, that they who were gathered there that evening should not only enjoy with Dr. Balfour that large sweep of public health, but that they should know that even the financial and fiscal affairs of this country were now being burdened—and he thought rightly burdened—with the great vital truth that unless a nation had a healthy race at its back it was idle to expect that that nation would either have a great future or would use its future for good. The primary asset of an empire was the health of its people. Statesmen and politicians had too often forgotten that fundamental fact.

There was one other word he would like to say about environment. We could never afford to bank only on the personal aspects of health. We could never afford to forget our sanitary history in England, or discard and neglect the environment; both were necessary. An enormous development of the one must not lead us to forget or ignore the necessity of the other.

The third and last point which had impressed him most in the paper was that of education. All education in hygiene, as Dr. Balfour had said, must carry the people with it. He was very deeply convinced of the truth of that observation. All true government was by the consent and assent of the people, but of all forms of government public and personal health was most dependent upon the consent and assent of the people; and it was rather disappointing when one considered on the whole the relatively small progress which was being made. "What," said a foreigner to him, "is this the land of Jenner, and you have an unvaccinated people!" It was an extraordinary thing. The lesson of Jenner had been copied throughout the world, and as far as he knew had never failed. The principle of vaccination was one which must be biologically true. The system of vaccination which a nation adopted might be defective and its vaccination laws might be clumsy or cumbersome, but vaccination must somehow or other be biologically true. Yet there were last week 168 fresh cases of smallpox—mild attacks, happily, but unnecessary and preventable. Only the other day there had been an outbreak of typhoid fever in the North of England where 52 cases had occurred which were milk borne from a farm where a case of typhoid was being nursed. It had been among Sir John Simon's earliest lessons that a case of infectious disease should not be nursed at a milk farm, but still the years went by and generation followed generation, and apparently each generation had got to learn by its own disasters. The history of typhoid in England was one of the most deeply instructive public health lessons in the whole of our literature. Yet we were suffering now from a gratuitous outbreak caused by something which it had been known in England for half a century was a monstrous thing to allow. The Schick test of diphtheria was another example. It was practised in New York, where it was used as an instrument of prevention, direct and immediate, on an enormous scale. Here, the truth of it was known as well as in New York, but it was only with difficulty that that useful test was made applicable. As a nation we were infected through and through with tuberculosis, and we knew the answer. The answer was the sanatorium principle, but this principle was not being practised in England by the people as a whole. Tuberculosis was one of the most preventable —he would go so far as to say it was one of the most curable—of all our great maladies. The majority of the population were infected with tuberculosis, but the majority survived. The sanatorium principle, however defective the sanatorium system might be, should be used in every home in the land in order to stamp out tuberculosis, which was our characteristic English disease, but it was not done. 700,000 mothers were going to give birth in the next 12 months to our future population, but not 200,000 of them would take the trouble or the precaution to have the full advantage of ante-natal treatment and care and supervision during their pregnancy. Childbirth was still left a hazard in England, whereas it should be a safe security for mother and child and State. It was known that ante-natal care of the mother during those precious 9 months was the only true common-sense of that vital event of priceless worth to the State; yet English people could not be got to accept the facilities which were provided.

Lastly, he wondered whether the English people would ever be persuaded to accept periodical medical examination. If they could, the tap of personal disease would be able to be turned off and the life of man prolonged. It had been prolonged. The great answer that public health was able to make was that the child born in London that night had a prospect of life of between 10 and 12 years more than had its grandfather. That was only two generations. He would like to see disease turned off at the tap, and he believed the only way to do that was to educate the people.

Sir William Simpson, C.M.G., M.D., F.R.C.P., said he looked upon Dr. Balfour as one of the foremost leaders in hygiene, especially tropical hygiene. Dr. Balfour always treated his subject from a practical point of view; he had what many others lacked, namely, imagination, and was able to look forward into the future. That gift which Dr. Balfour possessed had not been spoiled by the routine work which he had carried out either in the laboratory or in the field or in the office. Personally, he agreed with everything Dr. Balfour had said. He hoped that Dr. Balfour would give another lecture not on the trend of modern hygiene but on the trend of modern unhygiene. He quite appreciated all the advances which had been made and which would be made in the matter of hygiene, but he also recognised that there were opposing forces which marched parallel with these advantages and neutralised many of the benefits derived from them. He had seen a great change taking place during the past 25 years in the rebuilding of the residential parts of London. Low-storied houses with their gardens attached had been replaced by large blocks of flats without gardens, and so constructed to be close to other buildings behind them. These residential barrack buildings in their lower stories had neither the sunlight nor the ventilation that the former private houses possessed, and there was no playground for the children. Even the squares were threatened. Endsleigh Gardens was only one recent example of the blocking up of the lung spaces in London. A new Building Act was required for London to meet the new conditions, and to prevent the rapid disappearance of the health-giving open spaces. Recently it was proposed that the London County Council should erect on an area of St. Pancras, for the accommodation of the labouring classes, blocks of nine-storey flats in substitution of the two-storey houses that now occupied the site. Apart from the risks to the women and children in these huge buildings in the case of fire causing a panic, it was certain that the massing of the poorer labouring classes in immense barracks would not solve the housing question, but would eventually produce a new type of slums injurious to the health of the occupants. There was one point in connexion with the educative part of the matter to which he would like to refer. He did think that more than mere teaching in the subject of hygiene was needed. Hygiene could be better taught by means of museums. Just as there were national galleries for pictures, so there ought to be health museums, where every industry should be illustrated, the dangers which were attached to that industry and the modes by which those dangers could be avoided. He might mention in that respect that the Health Section of the Wembley Exhibition would be of great help. Last year he had been surprised at the number of children who had visited the health portion of the Exhibition.

DR. JOHN C. MCVAIL, M.D., LL.D., remarked that those who had been acquainted with Dr. Balfour's work and writings in the past had heard just the kind of paper that they expected they would hear—a paper distinguished by comprehensiveness, by wide knowledge, and enlightened by a pawky humour which was Dr. Balfour's own. Those who had not heard Dr. Balfour before would be relieved to know that men of his sort, along with the Chairman, were likely to be the greatest factors in the future of public health in England for another generation. They would recognise his breadth of view. They would see that Dr. Balfour, while filling his students with enthusiasm for public health, would prevent any one class of those students from thinking that their own particular little section of the public health advancement was the be-all and end-all. They would find that the bacteriologist would be taught that bacteriology was very important, but that it was a very long way from being everything, and that there was far more in public health than bacteriology. Even in health administration they would find that Dr. Balfour would tell future Medical Officers of Health that they were not to attribute everything which had happened in the way of advancement to Medical Officers of Health. When those officers were inclined to point to the diminution in scarlet fever, in whooping cough, in typhus fever and in measles, and to attribute all that to their own work, Dr. Balfour would tell them that there were other pebbles on the beach besides themselves.

He would like respectfully to add his testimony to the value of education. Reference had been made to periodic medical inspection and to the question of what was likely to be the value and the practice of it in the future. Education was necessary, alike of the general practitioner and of the professors, and of the public. The education of the public was the most important. A great deal of the improvement which had taken place in the general health of the country was owing to a gradually rising standard of knowledge and appreciation of the importance of health. With regard to the education of the profession and of the professors who taught the profession, that would go on apace. The General Medical Council had insisted that in the education of the student there should be a block system, by which no medical student was allowed, before he had passed his examination in one section of the work, to go on to the next section; he had to pass his examination in the first section before being allowed to proceed to the second section. All through, the subject of prevention would permeate the whole education; the student would hear of prevention in anatomy, in physiology, in physics, in therapeutics, and so on, and every one of his teachers would be a teacher of preventive medicine. The result would be that as time passed the medical profession would get the preventive point of view. As to periodic medical examination, he strongly held that that must be with the goodwill of the person examined. In America it was done through means of institutes, but he thought the best system would be by practitioners having groups of individuals in regard to whom they were responsible for their health. He was sure that that would be a very fruitful source of improvement in the standard of public health in the future, and he was certain that Dr. Balfour would share in bringing that desirable position to fruition.

DR. C. A. BENTLEY, D.P.H., (M.O.H., Calcutta), said he had just returned from India, and his attendance at the meeting that night had enabled him to satisfy two of his greatest ambitions, namely, first to meet Dr. Balfour in the flesh after having read his writings, and secondly, to have the pleasure of meeting the Chairman. Those practitioners who worked in India honoured many of those who were present that evening, especially Dr. Balfour and also Sir William Simpson. He would like to take the present opportunity of saying that medical men in Calcutta, both Indians and Europeans, still remembered with gratitude the work which Sir William Simpson had done there 30 years ago, which work was bearing fruit to-day.

He was afraid that Dr. Balfour was a little pessimistic in regard to India; but that was not his fault, because people in this country could only judge by the reports they received. There was also the fact that sanitarians had to be pessimistic in their reports in order to try to wake up the authorities to the great needs of the day. He might say, however, that there was at present a considerable advance over what had generally been supposed. For example, in Bengal there were Health Officers in every district. Some 300 assistant Health Officers were to be provided in the early future. That marked a great advance. There had also been a very great advance in the inauguration of voluntary public health work. A very notable movement had taken place in quite recent years. At the present time there were no less than 500 voluntary village Health Societies who were raising money amongst themselves and employing volunteer medical and other workers, and who were doing most excellent work in the prevention of malaria, cholera, tuberculosis and other diseases. They were making use as far as possible of the measures which had proved so successful already in this and other countries, but the necessary funds were lacking to apply those measures as they should be applied. It was not generally known how exceedingly poor India was, and the Provincial Governments and also the Local Authorities. The Bengal Government had for all purposes a revenue which amounted to about two rupees per head of the population per annum—roughly speaking about 2s. 6d. That was to meet every sort of expenditure. With regard to the prevention of disease, at the present time they could only manage to obtain a sum of about one-third of a penny per head of the population. Half-a-crown was a common price for a bottle of many patent medicines, but they in India had to get not merely remedies for disease, but everything else out of that paltry half-crown, and one-third of a penny for the prevention of disease did not allow of them doing as much as they should like.

He thanked Dr. Balfour for having emphasised the need for an Imperial outlook and for Imperial co-operation. In the case of Bengal, within three years cholera could not be stamped out, but it could be got under control, so that it would no longer be a serious danger to the community or a danger to other countries, and that could be achieved for an expenditure of about £50,000 per annum. No steps could be taken at the present time because the necessary money could not be obtained. Surely it should be a comparatively simple matter to raise that amount in this country by voluntary subscription. It might be possible to make use of the sort of idea that had been evolved just after the war in regard to the reconstruction of villages in France and Belgium. Certain communities in this country adopted towns and villages in Belgium and France and assisted the inhabitants there to restore their villages and towns. Why should not the same idea be adopted in regard to some of our Dependencies, such as India ? There were 84,000 villages in Bengal with an average population of 500. It would be a comparatively small thing for some of the large towns here to adopt a whole group of those villages, to give them assistance, to take a personal interest in those communities and to enable the local voluntary workers to deal with the eradication of disease, which was quite possible if the means were provided.

Dr. Arthur Haydon, M.D., referred to an extraordinary thing which he had discovered in the course of his insurance work in the east-end of London, namely, that Insurance Companies in the City of London refused to take the wives of men who had died of cancer. Why should that be so ? There was no blood relationship, and what possible connexion could there be between the man and his wife ?

He would like to call attention to the appalling increase in the number of cases of appendicitis. Only in that day's paper there was a record of 50,000 cases of appendicitis. He suggested that more supervision should be exercised over food commodities. He had personally reported to the Municipal Authorities two butchers for selling imported meat as English meat, but in neither case had the Municipal Authorities taken any action.

Dr. Charles Porter, M.D., (M.O.H., St. Marylebone), said that the last speaker had made reference to butchers; he, also, would like to refer to those gentlemen. The Chairman himself, through his Department, had very recently issued certain regulations relating to the practice of butchery and to the sale of meat by butchers, but the Chairman might have noticed that few butchers were obeying his regulations. Apparently the Ministry of Health had been receiving deputations from the butchers and had evidently listened with very favourable ears to what they had to say. That very morning he had received what had appeared to him to be an exceedingly threatening communication from the Ministry of Health requesting him to furnish explanations of why he was asking the unfortunate butchers to do anything. Dr. Balfour had referred to the necessity for co-operation and also to the necessity for the people themselves asking for things to be done on their behalf. Personally he was appalled at the lack of interest which the people took in public health, and particularly in food questions. It apparently had not yet dawned upon them that it was well to have their food as clean as they could possibly get it. If it had dawned upon the people that there was that necessity, he thought, perhaps, they might have gone to the Ministry of Health and urged pressure to be brought upon the butchers to obey the regulations which the Ministry had issued.

He desired to thank Dr. Balfour very much for his admirable lecture. It was a model of what such a lecture should be. He did not dwell too long upon any particular subject, and he treated all the subjects with a pawky humour which was bound to appeal even to an English audience.

The Chairman then proposed a hearty vote of thanks to Dr. Balfour for his exceedingly able and interesting lecture.

Sir Frank Baines, C.V.O., C.B.E., in seconding the motion, said had the hour not been so late he would have liked to express his layman's ideas on certain aspects of the question of hygiene which seemed to him to be of some importance. For instance, he regarded education as not necessarily being the cure for overcoming the difficulties which had been mentioned that evening. The great problem of education was to make things not non-palatable for the people but positively palatable, and he was certain that the people would refuse to carry out a very unpleasant dietary if it was distasteful to them. The problem was to make the people see that to follow principles of health was really following quite the jolliest and best form of activity in life. It was not at all jolly, if one lived in a small primitive village in this country, to drink from a well which was full of foul water, and yet that condition was existent in England to-day. The primitive conditions of sanitation in this country to-day in rural districts were really very bad, and in that connexion there was a very ample field for a great reformer, such as Dr. Balfour. He also hoped that sanitarians and those engaged in scientific hygiene, would not altogether forget the fundamental aspects of urban life, such as the pollution of the atmosphere. A great amount of illness was caused by polluted atmospheres, and if only sanitarians would take up that aspect of the matter, as well as the butchery side, he was sure the health of the people would be largely improved. As a layman he had often wondered whether the sanitarian and the hygienic reformer could state why to-day the population suffered so much from serious attacks of influenza.

It was impossible to produce a set of hygienic practices under the conditions in which the great mass of our population lived to-day in our central inland towns, where they had little fresh air and saw but little of the fresh green fields. Laymen therefore, called upon the sanitarian and the specialist in hygiene to suggest schemes by which modern conditions could be made bearable. It was almost preferable to die than to live under the conditions in which some of the population existed to-day He, therefore, suggested that it was up to a great reformer, such as Dr. Balfour, to look at that aspect of the question and see whether he could not suggest conditions which would affect a radical alteration in the method of industry and in the method which controlled the life of the people. The Chairman had remarked that disasters had great effects. The great plague of London had thoroughly altered the mediæval type of working in England. It had swept away the whole freedom of the Guild craftsmanship and had gradually prepared for the introduction of the industrial revolution. The industrial revolution was one of the greatest diseases of modern times and he would very much like to think that our leading sanitarians would see a way out of that difficulty.

The vote of thanks was then put and carried unanimously.

Dr. Balfour, in acknowledging the vote of thanks, said he was extremely glad to see present Sir William Simpson, at whose feet he had sat and from whom he had learned all he knew about tropical hygiene. He sincerely trusted that there would be instituted a museum of the type to which Sir William had referred. He had been a pioneer in recommending a hygiene museum, and he (Dr. Balfour) sincerely hoped that Sir William would live to see his idea brought to fruition.

With regard to Sir Frank Baines's remark about influenza, this was not a new disease, although long ago it was confused with many other conditions, and it might have taken on new features. He trusted with Sir Frank Baines that many of the conditions in rural England to which he had referred would be very soon altered.

MEETINGS OF THE SOCIETY.

Indian Section.

Friday afternoon, at 4.30 o'clock.

June 12.—Brigadier-General Sir Percy Sykes, K.C.I.E., C.B., C.M.G., "The Heart of Asia and the Roof of the World." The Rt. Hon. Lord Lamington, G.C.M.G., G.C.I.E., will preside. The paper will be illustrated with Special Coloured Lantern Slides.

Dominions and Colonies Section.

Thursday afternoon, at 4.30 o'clock :—

June 18.—Hon. W. G. A. Ormsby-Gore, M.P., Under Secretary of State for the Colonies, "East Africa." The Rt. Hon. J. H. Thomas, M.P., will preside.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

Tuesday, June 2..University of London, King's College, Strand, W.C. 5.30 p.m. Rev. J. K. Mozley, "The Doctrine of God." (Lecture II.)

At University College, Gower Street, W.C. 5.30 p.m. Profs. A. V. Hill and J. C. Drummond "Bio-Chemistry." (Lecture V.)

Wednesday, June 3..Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. R. Whittington, "The Passage of Electricity through Vacuum Tubes." (Lecture III.)

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 5.30 p.m. (Wireless Section). Dr. R. L. Smith-Rose, "The Effect of Wave Damping in Radio Direction-Finding."

Entomological Society, 41, Queen's Gate, S.W. 8 p.m.

University of London, King's College, Strand, W.C. 5.30 p.m. Mr. H. W. Steed, "Central Europe, Roumania and the Near East—From the Treaty of Berlin to the Treaty of Versailles."

Thursday, June 4..Royal Institution, Albemarle Street, W. 5.15 p.m. Prof. F. O. Bower, "The Natural Classification of Ferns." (Lecture III.)

Chemical Society, Burlington House, Piccadilly, W. 8 p.m. 1. Mr. W. A. Wightman, "The Spatial Structure of Cycloparaffins." Part I. "A new Aspect of Mohr's Theory and the Isomerism of Decahydronaphthalene." 2. Messrs. T. A. Henry and H. Paget, "Chenopodium Oil." Part II. "The Hydrocarbon Fraction." 3. Messrs. J. A. Goodson and T. A. Henry, "Echitamine."

University of London, at King's College, Strand, W.C. 6.30 p.m. Dr. O. Vocadlo, "The Czechoslovak Republic To-day." (Lecture VII.)

Institut Français du Royaume Uni, 3, Cromwell Gardens, S.W. 6.15 p.m. M. M. Thiéry, "Les Journaux de la Révolution."

Friday, June 5..Royal Institution, Albemarle Street, W. 9 p.m. Mr. Howard Carter, "The Tomb of Tut-Ankh-Amen."

Geologists' Association, University College, Gower Street, W.C. 7.30 p.m. 1. Messrs. A. J. Bull and H. B. Milner, "The Geology of the Eastbourne-Hastings Coastline." 2. Mr. G. S. Sweeting, "The Geology of the Country Around Crowhurst."

Philological Society, University College, Gower Street, W.C. 5.30 p.m. Mr. W. Worrell, "Dictionary Evening."

Shakespeare Association, King's College, Strand, W.C. 5.30 p.m. Mr. R. C. Rhodes, "Dramatic Piracy from Shakespeare to Sheridan."

Saturday, June 6..Royal Institution, Albemarle Street, W. 3 p.m. Rev. E. M. Walker, "Democracy in the Ancient World." (Lecture III.)

JOURNAL OF THE ROYAL SOCIETY OF ARTS

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FRIDAY, JUNE 5, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

FRIDAY, JUNE 12th, at 4.30 p.m. (Indian Section.) BRIG.-GEN. SIR PERCY SYKES, K.C.I.E., C.B., C.M.G., "The Heart of Asia and the Roof of the World." (Illustrated with Special Coloured Lantern Slides.) THE RT. HON. LORD LAMINGTON, G.C.M.G., G.C.I.E., will preside. Tea and coffee will be served in the Library from 3.45 p.m.

COUNCIL.

A meeting of the Council was held on Monday, May 18th. Present:—Lord Askwith, K.C.B., K.C., D.C.L., in the Chair; Sir Charles H. Armstrong; Sir Frank Baines, C.V.O., C.B.E.; Sir Charles S. Bayley, G.C.I.E., K.C.S.I.; Lord Bearsted, LL.D.; Captain Sir Acton Blake, K.C.M.G., K.C.V.O.; Sir Archibald Denny, Bt., LL.D.; Rear-Admiral James de Courcy Hamilton, M.V.O.; Col. Sir Arthur Holbrook, K.B.E., M.P.; Sir Herbert Jackson, K.B.E., F.R.S.; Major Sir Humphrey Leggett, D.S.O., R.E.; Lieut.-Col. Sir A. Henry McMahon, G.C.M.G., G.C.V.O., K.C.I.E., C.S.I.; Sir Philip Magnus, Bt.; Hon. Sir Charles A. Parsons, K.C.B., LL.D., D.Sc., F.R.S.; Sir George Sutton, Bt.; Mr. Alan A. Campbell Swinton, F.R.S.; Mr. Carmichael Thomas; Dr. J. Augustus Voelcker, M.A., Ph.D., and Sir Philip Watts, K.C.B., LL.D., F.R.S., with Mr. G. K. Menzies, M.A. (Secretary of the Society) and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections.

A resolution of sympathy with Lord Leverhulme was passed on the death of the late Lord Leverhulme, a Vice-President of the Society.

The question of the award of the Albert Medal was further considered.

Preparation of the balloting list for the new Council was begun.

The entries for the second series of the Examinations were reported. These are 46,778. The entries for the first series were 27,568, making a total of 74,346, as compared with 71,081 in 1924, an increase of 3,265.

Papers and lectures for session 1925-26 were considered.

Arrangements for the visit of Fellows of the Society to the Croydon Aerodrome were considered.

Other formal business was transacted.

VISIT TO CROYDON AERODROME.

At the Ordinary Meeting held on May 6th last, when Air Vice-Marshal Sir Sefton Brancker read a paper on "Commercial Aviation," a suggestion was made that Fellows of the Society might like to visit the Aerodrome at Croydon. Sir Sefton Brancker communicated the proposal to the Air Ministry, who have now intimated their readiness to receive a party of twenty Fellows at the Aerodrome on Thursday, June 25th, and a similar party on Friday, June 26th, at 3 p.m.

Fellows of the Society who desire to avail themselves of this invitation are requested to communicate at once with the Secretary of the Royal Society of Arts, John Street, Adelphi, London, W.C. 2. In doing so they should state whether they will be able to attend on either day.

The number of visitors has to be strictly limited so as to permit of those who accept the invitation being shown over the Aerodrome.

Tickets of admission will be issued in the order in which applications are received.

TWENTY-THIRD ORDINARY MEETING.

WEDNESDAY, MAY 27th, 1925. SIR ROBERT ABBOTT HADFIELD, Bt., D.Sc., F.R.S., in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Bhajiwalla, Edy Jehangirji, Bombay, India.
Bhajiwalla, Hormusji Jehangirji, Bombay, India.
Camp, Lee G., Havana, Cuba.
Castellani, Aldo, C.M.G., M.D., F.R.C.P., London.
de la Macorra, José, jun., Mexico City, Mexico.
Guthrie, David Leslie, London.
Mistry, Munchershaw Pherozshaw, Bombay, India.
Mitchell, Lieut.-Colonel Archibald Maclaine, D.S.O., Edinburgh.
Overbeck, Otto, F.C.S., Grimsby.
Pitman, Isaac James, Bath.
Rice, Sidney A. S., London.
Shaw, Arthur H., M.I.E.E., M.I.Mech.E., Ilford, Essex.
Timson, Ernest Arthur, Kettering.

The following candidates were duly elected Fellows of the Society:—

Hooper, Lewis John Eric, London.
Krause, Dr. Heinrich, Chicago, Illinois, U.S.A.
Plummer, William Thomas, London.

A paper on "The Unemployment Problem" was read by the RT. HON. SIR ALFRED MOND, Bt., M.P.

The paper and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

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TWENTIETH ORDINARY MEETING.

WEDNESDAY, MAY 6th, 1925.

MR. ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council of the Society, in the Chair.

THE CHAIRMAN, before the paper was read, said that the Duke of Sutherland, who was to have taken the Chair, was unfortunately unwell, and as a late Chairman of the Council he had been called upon to preside. It was quite unnecessary for him to introduce Sir Sefton Brancker, who was already so well known to nearly all those present.

The paper read was:—

COMMERCIAL AVIATION.

BY AIR VICE-MARSHAL SIR WILLIAM SEFTON BRANCKER, K.C.B., A.F.C., Director of Civil Aviation, Air Ministry.

The title of my paper is "Commercial Aviation," a broad subject on which I could talk for several hours. But I am going to confine myself to air transport as it affects the British Empire. I want first of all to explain to you what has been done by air transport in the past. It will be old news to a good many of those present, but some recapitulation is necessary. Then I shall try to prove that air transport is going to be of very vital importance to the Empire in the future.

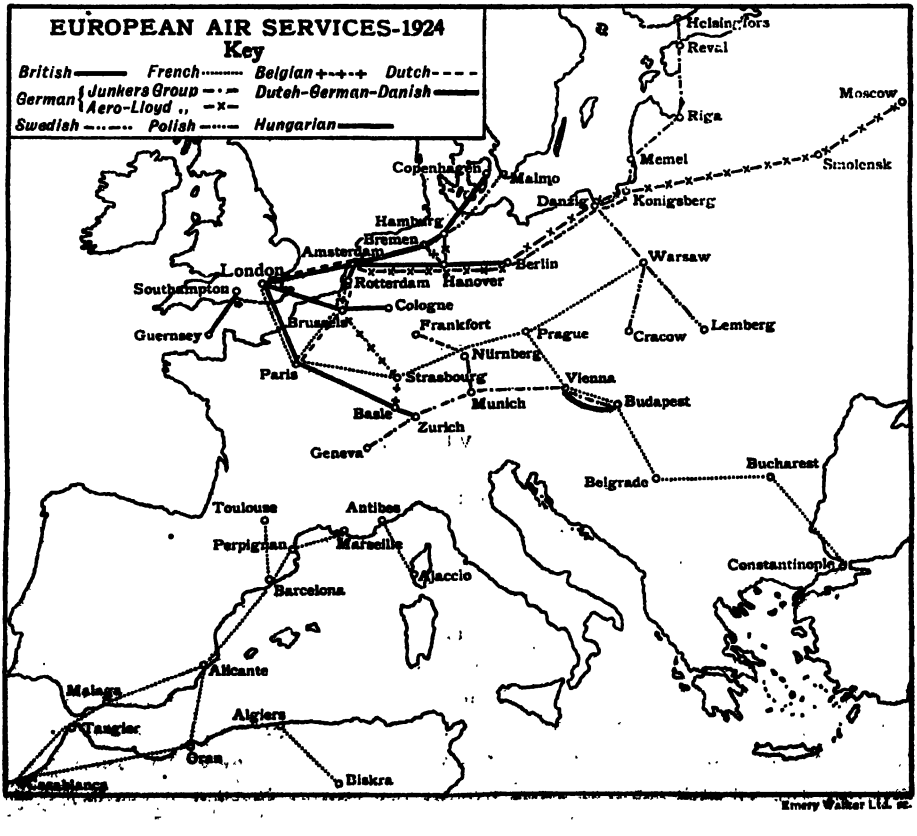
Air transport was a war baby. It arrived in this world almost immediately after the Armistice, and it squealed very loudly. It was an ill-fed child, very unpopular with the Government, and did extremely badly in its early days, owing to general starvation and neglect. The people who plunged into air transport with faith and enthusiasm after the war found themselves up against a very difficult task, because the whole of our standards, after five years of war in the air, were wrong—wrong in equipment, personnel, and everything else. War had done much for aviation, but it had not taught us anything about the basic factors in air transport as a commercial proposition—namely, economy, regularity, and speed. War flying was conducted regardless of expense and in the face of terrible danger, and those two factors led the public to believe that aviation was a costly and a dangerous operation. War experience also led commercial organisations, which tried to take up flying as a commercial proposition, into completely wrong ideas as to the cost and the way in which it should be run.

It was obvious to me and to certain others at the beginning that this new industry could not possibly support itself until it had put its house in order and had delivered itself from war conditions. During the past five years France, Germany, Holland, America, and ourselves have been trying in this respect to turn our swords into ploughshares, but at the end of those five years, we in

Europe, at all events, are reluctantly forced to confess that to-day a subsidy is still necessary to enable air transport to operate, except in unusual circumstances, without a loss, and it is rather to justify that subsidy that I am speaking to-night.

I will not enter into details as to the different national policies. It is sufficient to say that France and Germany, on the one hand, have been far more liberal in their support of commercial aviation and air transport than we, and that America, on the other hand, one of the leading business nations of the world, has absolutely refused to give any form of public assistance to private enterprise. America has been running an extremely efficient Government air-postal service for the last three or four years. In America there has been state control; in Europe there have been Government subsidies for private enterprise.

At the end of these five years we find commercial aviation in Europe proceeding as marked on the map I now place on the screen. To take the British enterprises first, we are flying to Amsterdam and Berlin, through Brussels to Cologne, and through Paris to Basle and Zurich. These operations are now



carried out by one company—the Imperial Airways Company—subsidised by the British Government. Some of these services are run as often as three times a day, others only once a week. The French have some long routes besides their services to London and to Amsterdam; they have been flying right across Strasburg, Prague, Vienna, Budapest and Belgrade to Constantinople, together with a branch to Warsaw. Owing to various international squabbles that line is now in a state of suspension, because the Germans have forbidden them to fly from Strasburg to Prague, and the Turks have forbidden them to fly over Turkish territory. The French also have a most efficient air service down the east coast of Spain to Morocco.

German aviation is at present, again owing to international complications, largely confined to Central Europe. The Germans are flying from Berlin to Amsterdam, and occasionally to London. They also fly from Frankfort to Munich and Geneva, and from Vienna to Budapest; and certain lines to the north, to Copenhagen and Helsingfors, are absolutely under German control.

These developments in Europe have been considerably hampered by the fact that almost every nation, and particularly every small nation, looks upon air transport as a sort of military reserve. There is not much belief in it from the commercial point of view, and in consequence every nation wants to have its own aircraft and pilots, whereupon the position at once becomes impossible, because the only way—it is obvious to everybody—to get air transport down to a solid commercial basis is to have standardisation of equipment, methods of administration, and control over large areas. I think the history of air transport in the future will be very much the same as the history of railways. If you study the history of railways in England you will find that they started with a vast number of small companies, all of which were gradually absorbed until to-day we have only three or four great companies which have absorbed all the others. At the head offices of the Great Western, for instance, I have been shown as many as eighty "scalps"—that is, the seals and crests of old companies which the Great Western has absorbed in the past. That must happen with the air service in Europe. These companies must eventually come under one control, and we must try to ensure that this shall be, if possible, British control.

You will realise from the map that France is the only country which has operated lines of serious imperial importance. She has connected up, for instance, through Spain to Casablanca, in Morocco—the biggest port in French Morocco—and this year she is going to take that line on to Dakar. The French are treating aviation as a means of imperial communication. They have adopted a somewhat expensive form of subsidy. What it amounts to is that the French commercial companies are encouraged to keep a large fleet and staff of pilots; they are paid according to the number of aeroplanes and pilots that they keep in commission. The result is that they have a considerable number of pilots and aircraft in operation.

The Germans have another system. The policy of one of the big German firms is to try to start subsidiary companies in every country; to provide those companies with their fleet complete in exchange for shares and perhaps a little cash, and to guarantee the repair of those aircraft at a standard rate in some central German factory. Thus it is hoped slowly to distribute German aircraft throughout Europe and perhaps the world. In this we have an interesting contrast with the French method. The French establish communications on lines which will ensure a large number of pilots and aircraft; the Germans, on the other hand, try to extend their exports and manufactures.

We have adopted neither method, and I think our plan is the best from the commercial point of view. We have made a contract with the Imperial Airways Company for ten years, on the understanding that they would fly a million miles every year, and a monopoly of subsidy within Europe was given to the Company on that basis. The subsidy totals £1,000,000 and is arranged on a sliding scale of decreasing payments over the ten year period. Beyond this, all we require, is that the personnel must be members of the Royal Air Force Reserve. The Company has absolute freedom as to where they operate in Europe. Our subsidy is less in total than that granted by our neighbours, but the scheme is such as to make the company concerned force commercial aviation on to strictly business lines, cutting their fleet down as much as possible, and getting the maximum possible work out of their machines, pilots, and mechanics. The result is that to-day, if you take the amount of money we and the French have spent, you will probably say that we have come out worse in numbers; but the fact is that if we go on as we are doing, we shall soon arrive at a point where our air transport pays its way, and arrive at it considerably sooner than these other people who are subsidised on a different basis. And if we can do that, we shall have the world at our feet; commercial aviation will never really succeed until it can dispense with Government subsidy and financial support. When it does that, it will boom in every part of the world, and if we reach a paying basis before our rival, we shall benefit greatly.

What has been accomplished in these five years? I have said that air transport cannot pay its way to-day. The reasons for this failure are two. In the first place, the public are not using air transport sufficiently; and, in the second place, the type of aircraft at present in use costs a little too much per ton-mile for real commercial success, except under special conditions. Before we can do without a subsidy, therefore, we have to make the public use air transport more than they do at present, and we have got to improve our design. On both these lines we are doing our best. Our first duty is to educate the public to the use of aviation, and I am sometimes driven to think that we shall have to wait until every one now over 40 years of age, including myself, is dead before air transport comes into its own! It is only the young and enterprising men who will absorb it quickly and realise its possibilities.

In studying the question of the public's requirements, I maintain that the first is safety, and the second reliability, together with some appreciable saving of time. Comfort in travel is also a necessity, and another condition is comparative lowness of cost. All these the Government is striving to obtain, and in the money we are spending on research as regards commercial aircraft equipment and so on, these are the objects we have in view—safety, reliability, and economy.

I will now give you some facts and figures to demonstrate the progress made since the end of the war, showing you in the first place one or two of the types of machines operating to-day, including the D.H. 34, carrying eight or nine passengers at about 90 miles an hour, and also the latest type of flying boat which is shortly going to be taken in service by Imperial Airways. I think the big flying boat of the future is going to be one of the most important factors in the development of British air transport.

The three requirements I have mentioned are safety, reliability, and economy. Take safety first. I place on the screen a record of the miles flown during the last five years and the actual number of accidents.

	Miles flown.	Number of fatal accidents.
1919	100,000	1
1920	640,000	1
1921	225,000	0
1922	717,000	0
1923	943,000	1
1924	936,000	1
1925 (part)	190,000	0

Thus we have flown in regular air transport—these are regular lines flying every day, not the casual " joy rides"—134 times round the equator and there have been only four fatal accidents. All these accidents were avoidable. We are learning by experience how similar accidents can be avoided in the future.

Next take regularity. I will give you only one example. In 1924 Imperial Airways actually started 4,250 flights during the year, and only 7 per cent. were interrupted—5 per cent. by weather, and 2 per cent. by some mechanical defect, such as engine defect, entailing a landing to put things right. The weather in this country is just about the worst in the world for aviation. The real enemy of air transport is bad visibility, and the further east we get, in the direction in which our big imperial communications extend, the easier will the weather conditions become. Mechanical failures can be overcome by more experience, and by improvement in design and maintenance, and we are working hard at that problem. I think that this 7 per cent. in about five years' time will drop to perhaps 1 per cent. On the one hand the greater stability of our new aircraft and on the other improvements in wireless navigation will enable us to fly in worse weather, whilst with the increasing reliability of our engines, unreliability through mechanical defects should disappear altogether.

The next thing the public want is low cost and time-saving. I show a table of the services from London. The time saved between London and Paris is nearly 4½ hours; the difference in fares is £3; but it must be remembered that between London and Paris there is a luxury traffic, and the prices are kept up because the traffic can be obtained at that rate. In the journey from London to Berlin 15 hours are saved, and the air traveller is charged only 18s. 7d. extra. From London to Hanover the saving is 14½ hours, and the cost 12s. extra, and from London to Amsterdam, 9½ hours, 12s. extra. Still, the public are not using these services as they ought to do, because they have not yet learned the great advantages travelling by air offers. Not only are you saving time by travelling by air but also worry and discomfort, and all the jostling involved in changing from the train to the steamer and *vice versa.* The air gives a very much higher standard of comfort. We hear a great deal about air sickness, but air sickness is vastly preferable to sea sickness, and I think we have discovered an *apéritif* by which, if it is taken beforehand, air sickness will almost invariably be staved off.

The further you go the more you save in time, and the lower in proportion will be—at least, I think it very likely—the extra cost. The airship journey to India in the future may save ten days and probably the charge will be about the same as the first-class fare via P. and O. to-day. At the end of the war 10s. per ton-mile was stated roughly as the cost; to-day we have reduced it to about 4s. 6d. per ton-mile. Our trip to India the other day cost 2s. a mile, and the machine would have carried about 1,000 lbs. of paying load, with four hours' fuel, which works out at about 4s. 6d. a ton-mile. At the end of the war military experience had taught us that a pilot could be depended on to fly for about 200 hours in the year. To-day some of them have been flying 1,000 hours in a year, and the average pilot flies 700 hours. Individual aircraft have done 2,000 hours in the year, and the average is 1,100, whereas during the war 250 hours was considered to be about the limit possible.

My next slide gives some idea of the work that is going on. It shows the trips of the Imperial Airways fleet during a typical month. You will see that one Handley-Page has been 70 times between London and Paris in the month, and it has also been from Paris to Basle twice, and from Basle to Zurich twice. Other machines have made more varied journeys. Properly administered and looked after, it is evident, that our system of subsidies drives the operating company to make the best use of their aircraft, and if similar returns of either the French or the German companies were examined, I do not think you would find anything to touch this in the way of obtaining work out of each individual unit of the fleet. We are now designing aircraft which will be more economical to run. We are hoping to get machines which will carry 5 lb. paying load per horse power in the near future; the best to-day works out to about 4.3 lb.

Public support is improving. I have here a table showing how the total transport across the Channel has steadily gone up during the last five years. In 1919 the passengers numbered 870; in 1923 they numbered 15,552. Last year there was a falling off because during the two most important months of April and May there was trouble with the pilots and all operations ceased. Freight is also going up; it was 541 tons in 1924, and it will be very much more, I think, this year. The peak of traffic has been steadily growing higher, though it is still very seasonal; it drops right down to nothing in the winter, and goes up in the summer. Accidents have their effect, but the public are beginning to realise that aviation, like the railway, must have occasional accidents without being regarded as a dangerous means of transport. One of our problems is to fill up the gap during the winter, when the traffic is so low. When the business man uses the air more, he will not be affected by winter or summer so much as the luxury passengers, and as the parcels traffic goes up the seasonal variation in load will be less accentuated. We are getting a most varied lot of freight in these days. On examining the Customs returns one finds every sort of thing coming over by air—ladies' hats, gramophones, eggs, chickens, boots, clothing, wine, drugs, flowers, samples of all sorts, solid gold, tobacco (in large quantities), and even motor bicycles. This shows that there is a considerable value in air transport as a means of carrying goods.

All these cross-Channel operations start and finish at Croydon aerodrome. I show a photograph of Croydon aerodrome as it was about a year ago. Since that was taken, improvements have been made, and greater ones are projected. Presently we shall have a very big aerodrome of practically twice the size it is to-day. The policy has been agreed and a certain amount of money is going to be expended this year; but it will probably take us three years to complete the scheme. At the end of that time we ought to have one of the finest air ports in the world. The commercial companies working from there have to pay Government landing fees and rent for sheds, and that money goes towards the upkeep of the wireless and meteorological organisations and the general maintenance of the station.

I cannot go further without mentioning airships. Airships are not rivals to aeroplanes. They will take a very leading part in air transport in the future. I am of opinion that you should never fly less than, roughly, 1,000 miles in an airship, and never more than a 300 miles stage in an aeroplane. The aeroplane is essentially suited for local traffic and short stages. If you fly long stages with an aeroplane you have to carry so much fuel that you reduce your paying load to an uneconomical amount. On the other hand, the airship, being full of gas, can support itself in the air, and uses all its horse-power for propulsion and can, therefore, cover far greater distances with an economical load. Generally the policy of the British Government is to organise an airship route to India. This is a view of R.34, a very old-fashioned ship, built from designs cribbed from one of the Zeppelins which came down in this country in 1916, therefore a 1915 pattern. Her speed is only about 45 to 50 miles an hour, she has 1,500 h.p., and nearly 2½ million cubic feet capacity.

The new airships, one of which is being built by the Government, and the other by Commander Burney's company, are more than twice the size of R.34, with 3,500 h.p.; they carry 100 passengers in comfort, all in two-berth cabins, with a dining room containing, I think, 50 seats, and a lounge containing 100. They go at a speed of 70 to 80 miles an hour. R.33, the other day, was good enough to prove that all we had said about the safety of airships was true. The ship of the future will be specially designed to be anchored to a mast twice as high as that from which R.33 broke away at Pulham, and instead of the passengers having to walk up a perpendicular ladder, they will be taken up in a comfortable electric lift, they will enter the airship through an opening in the nose, and will never realise that they are high in the air at all.

So far I have tried to prove to you that air transport is going to be a practical commercial proposition. We, as a nation, have certain disadvantages at home and certain great advantages abroad. England is rather a hopeless place for air transport. We are right on the edge of Europe; no one wants to cross us to get somewhere else; our climate is bad; our railways are good. But take Germany or Czecho-Slovakia. Germany has got a large area, a central position—people want to cross Germany from all sides—and I do not think her railway communications are nearly as good as ours. The same applies to Czecho-Slovakia.

But when we look round the world, we find that we have greater advantages than anybody else. If we compare the British Empire with the United States, we find ourselves coming out top every time in the distances we have to cover, and that is the great objective of air transport—the shortening of time for long distances. The United States have started right in on business-like lines. They refused to have anything to do with subsidising private business, and their Post Office began by carrying mails from New York to San Francisco. The mails took two days to get across. They did not charge the public anything extra for air postage. Now they have organised the central stretch of this transcontinental journey for night flying, which shortens the journey to 36 hours, and they are beginning to demand a surcharge from the public. They believe that the public have become educated now to the point of insisting on air mails, and will be willing to pay the new surcharges. They are going to do 2,700 miles in 35 hours, and the average time by train is about 100 to 120 hours. That is where America scores over us, so far as the British Isles are concerned. She has got that wonderful extent of country, she is not troubled by the international complications which flying across Europe involves, and she has a good climate for flying.

In the British Empire the bright spot is Australia. The map on the screen indicates what they are doing in Australia to-day. The most interesting route is Perth-Derby, along the coast of Western Australia, 1,500 miles in 2½ days (they do not fly by night), while the steamer takes anything from a week to ten days. Contracts are being called for already to connect Adelaide with Perth. You may say that Australia is already stretching out friendly hands towards us on her western coast.

What is our greatest failure in the British Empire? It is that we have too many people in this country, and too few in our Overseas Dominions. Here we are overcrowded and have a million people not fully employed; there they are sparsely populated and are calling for men. The only remedy for this unfortunate state of affairs is to improve our imperial communications. To that end every form of transport is necessary. We want more railways and more shipping, but aviation is going to play a large part in this development, and it can be the advance guard of other forms of transport. It can quicken the mail, and it can make possible visits of negotiation and investigation, which will stimulate business of every sort by saving time in communication. I show a map which may seem to be somewhat fantastic, illustrating the fact that through airship services from London to Australasia and to Durban, New Zealand will be brought somewhere near Somaliland in respect of time taken to travel, India will be where Egypt is, and South Africa somewhere near French Morocco. All great empires have depended on their communications for their existence—the Romans on their roads, and we so far upon the sea—and those empires which have gone down owed their eventual collapse to the fact that their communications became overstrained. It is only by improving our communications that we can develop imperial trade as we ought, can avoid misunderstandings and loss of touch, and promote mutual co-operation.

I am just back from reconnoitring one small stage in imperial communications, that between England and India. There are many ways of getting to India. The way we actually followed was through Berlin, Warsaw, Bucharest, Constantinople and so to Karachi, and then across to Rangoon; and we came home via Constantinople, Belgrade and Vienna. I have always been an optimist, but I did expect some difficulties. These difficulties, however, proved far smaller than they had appeared to be from a distance, and I came back a greater optimist than ever. From the operational point of view there is nothing to prevent a regular service between London and Karachi. There are no serious difficulties anywhere on that route, except possibly where the mountains must be crossed, in fact it is an extraordinarily easy route. We had very bad weather as far as Bucharest, but once past Bucharest we never thought about the climate until we got back to Vienna; we ran just as a railway train, and were never once delayed by weather from Bucharest onwards on the way out and back until we reached Prague on the way back. One of the things that struck me more than anything else was the absolute absence of fatigue. It is really true that the more I was in the air the fresher I felt. There was nothing of an adventure about this journey. We had a certain number of difficulties simply because the route is not yet organised. The whole enterprise was much easier than anyone realises. It is merely a question of finance as to how soon it will become a really successful commercial proposition.

Our prosperity in the past has been due to the fact that we have been a nation of seamen. I feel that now we have to become a nation of airmen, if we are to keep our place in the world. The British man is particularly well suited for the work of a pilot; in fact, our pilots are better than any others. Beyond this, we must build aircraft just as we have built ships in the past. It is only thus that we can create a race of pilots and develop our aircraft constructing industry on really efficient lines. It is no good saying " Wait and see." We can only learn by experience, and only by operating are we going to get what we want. When once air transport pays its way it is going to boom in every part of the world. The moment the business man realises that he can make money out of air transport he is going for it tooth and nail. As a result there will be an enormous demand for commercial aircraft, and the country which gets the orders is going to have a very fine industry indeed. That time is not so far off as a great many people think. A representative of Mr. Henry Ford came over recently to see me and other people in Europe, and he said that under American conditions they could produce aircraft to-day which would pay its way, that is, of course, in a country which has the advantages of good climate, large distances, and big populations. As a business man Mr. Henry Ford is going to plunge into that, and Mr. Ford is certainly no fool. We must keep pace with other people, and see that we get a fair proportion of the world's aircraft orders.

Then we must realise the fact that once we establish a great aircraft manufacturing industry, we shall automatically create a great reserve of pilots, factories, designers, and everything we want in the case of a national emergency. This industry will represent far greater resources than any standing Air Force we could afford to maintain. We do not want war. Aviation has made war more horrible than ever it was before. Sir Hugh Trenchard said the other day that he would like " to abolish the air." Well, I would not go so far as that. But the British Empire from the military point of view would be infinitely better off without aviation, for by reason of its advent we have lost the protection of the Channel and we have lost our isolation. All I would plead is that as we have to face the unpleasantness of aviation, we should grasp the good things that it can give us, and make real use of it in binding our Empire together more firmly and more sincerely than it has ever been bound before.

TABLE I.—British Civil Aviation.

(Excluding joy-riding).

Period.	Machine Flights.	Machine Mileage.	Passengers Carried.	Cargo Carried.
				(Tons)
May, 1919-December, 1919 ...	467	104,000	870	35
January, 1920-December, 1920 ...	2,854	644,000	5,799	120
January, 1921-December, 1921 ...	993	225,000	5,256	43
January, 1922-December, 1922 ...	3,625	717,000	10,393	183
January, 1923-December, 1923 ...	4,765	943,000	15,552	326
January, 1924-December, 1924 ..	4,892*	936,000*	13,601*	541*
January, 1925-April, 1925 ..	990†	190,000†	2,000†	133†
Total ...	18,586	3,759,000	53,471	1,381

* These represent only 10½ months' actual operations, as services were suspended during April and the first part of May.

† Approximate figures.

TABLE II.—Fares and Approximate Times by Ordinary Means of Transport as Compared with Air Transport.

	Time by ordinary Transport.	Time by Air Transport.	1st Class single fare by ordinary Transport.			Single fare by Air Transport.			Time saved by Air.	Difference in Fares.		
	Hours.	Hours.	£	s.	d.	£	s.	d.	Hours.	£	s.	d.
London-Paris ...	7	2½	3	5	0	6	6	0	4½	3	1	0
London-Paris-Basle-Zurich ...	10½	8	5	17	6	9	0	0	11½	3	2	6
London-Brussels ...	7½	2½	3	4	0	4	4	0	5	1	0	0
London-Cologne ...	15	3½	3	17	6	6	0	0	11½	2	2	6
London-Amsterdam ...	12	2¾	3	8	0	4	0	0	9¼		12	0
London-Hanover ...	20	5½	5	13	0	6	5	0	14½		12	0
London-Berlin ...	22	7	7	1	10	8	0	0	15		18	2
Southampton-Guernsey ...	6½	1¾	2	3	6	3	0	0	4¾		16	6
									76	£12	4	8

An average of about 3s. 3d. extra cost for each hour saved, not counting the fact that the journey by air saves appreciably in tips, taxis, meals, and sleeping berths.

DISCUSSION.

Major C. C. Turner remarked that he could only agree with nearly everything the author had said, and he would much rather leave any discussion to the several transport experts present. He thanked the author for his inspiring remarks.

Captain Alfred Instone congratulated the Society on the lecture, whose author had just recently certainly made history in commercial aviation. His object had been to create a greater public interest in that subject. As one who had had some experience in connexion with it the speaker felt that the greatest danger with which civil aviation had to contend was public apathy. There was assuredly no greater advocate of aviation than Sir Sefton Brancker. Since he entered upon his office Sir Sefton had been the greatest tonic that commercial aviation in this country had ever had. But the speaker had always thought that if only Sir Sefton were outside the Ministry his criticisms would awake everybody. He remembered Sir Sefton several years ago as an outstanding critic who, notwithstanding the figures and plans he had produced that evening to show the progress of aviation, could, no doubt, to-day, if he were outside the Ministry, equally prove by figures and plans that there was still much to be done before it could be said that all was well with commercial aviation. The speaker felt that sufficient tribute even at this stage had not been paid to Sir Sefton for his wonderful journey to India. That was a landmark in this country's air history. It surprised him to hear Sir Sefton say that the trip was plain sailing from one end to the other. He felt that, in view of the problems which arose in making these journeys, he had gilded the pill in this respect. There were one or two things which worked out to the disadvantage of civil aviation. One was the number of accidents which were taking place in R.A.F. work to-day. When the public heard of " air crashes " it did not discriminate between military and civil aviation. The sooner the public realised that these accidents had nothing to do with civil aviation the better. The task before Sir Sefton Brancker could not be improved by these European squabbles, which impeded the progress of routes through the Continent to-day. He thought that the public should back up any action that might be necessary in this country, so that British machines could cross Europe without difficulty and without international entanglement. It was a Government necessity that the obstacles placed in the way of aviation progress should be overcome.

Mr. R. à-Ababrelton said that he had heard Sir Sefton Brancker about a year ago, when he thought him an optimist, but he was a greater optimist still on the present occasion. The speaker was one of those who believed that the British Empire must be kept as an entity, and that everything that could be done to bring together the different nations that belonged to the Empire was of great benefit, not only to the Motherland, but to the Empire as a whole. One could see plainly that aviation was drawing together the different portions of the Empire in a way in which they had never been drawn together before. It was a great imperial service to assist the progress of aviation, not only in its commercial aspect, but as something strongly binding together the scattered portions of the Empire.

Mr. F. Handley Page, C.B.E., thought that Sir Sefton Brancker was to be congratulated on still being an optimist, because progress seemed terribly slow to those interested in aviation and those who desired to see the general public take a greater interest in it. Sir Sefton's map of air routes in Europe, in Australia and in other parts of the world seemed to have remained very stationary during the last two or three years, though, happily, there was not retrogression. But when one looked at the number of passengers travelling on the London-Paris route and the proportion of these who travelled in British machines, it was sad to find that the number in 1924 was no greater than it had been in 1922, whereas the number of passengers by French machines was steadily increasing. Another deplorable feature was the big dropping off in traffic in the winter months. He believed the real fact of the matter was that during the winter time, under present technical conditions, it was not possible to drive a sufficient number of times in daylight to carry the necessary load. Again, the parcel traffic between London and Paris was only obtained by carrying parcels at a figure which, if a passenger could go as a parcel, would represent something less than the first-class railway fare between the two cities. The greatest difficulty of all lay in the fact that we were not so very far removed, from the point of view of progress, from the war days, with their old machines. At the present time he thought there was extraordinarily little incentive to progress in the design of commercial aircraft. He said this with very great regret. If a manufacturer of aircraft to-day desired to do something for commercial aviation and designed a new type of aircraft he might, if he was fortunate, have an order for one machine; if he was still more fortunate, for two; three or at the utmost six would represent his highest hopes. The order was not of that magnitude which would help to relieve the vast amount of unemployment existing in this country. On the other hand, a successful military design might produce an order for fifty or one hundred machines. It was inevitable, therefore, that the manufacturer should turn to the mammon of unrighteousness in the shape of military aviation rather than to civil. That led the speaker to the point that, after all, the French system of subsidy was not such a bad one when one considered that it was not merely operational function that had to be undertaken by civil aviation, but the development of machines for the time when a subsidy would no longer be necessary. What one wanted to aim at to-day was a new fleet every year with new improvements, marking a stage forwards towards a cheaper machine. The French under their system legislated that machines should only fly 200 or 400 hours, and that was found to pay. He admitted that it was a most laudable thing and one worthy of congratulation when a machine was able to do two thousand hours of flying, but it had the disadvantage that while these records were pursued no new machines would take the place of the old; neither did the operational companies desire any new machines. The present subsidy conditions in this country were to a very large extent stultifying the development of progress in commercial aviation. He added that it was with a feeling of regret that in the presence of one (Sir Sefton Brancker), who was confessedly an optimist, he appeared in the necessary though disagreeable rôle of pessimist.

Wing-Commander T. CAVE-BROWN-CAVE, C.B.E., suggested, with a view to securing a larger measure of public interest in civil aviation, that visits to Croydon should be encouraged. He could confidently recommend a visit to Croydon as being " one of the best shows going " of its type.

COLONEL W. A. BRISTOW said that the whole point in civil aviation was that while the factor of safety had been brought up to the necessary high level, the actual cost of carrying a passenger remained greater than the amount that a person could afford to pay for being carried. Consequently, any increase in the number of passengers must for the moment hamper any company, which was bound to look at its balance sheet. If a private company with its shareholders to consider was entrusted with the task of developing imperial aviation it was being given something to do which was almost beyond its strength. As Mr. Handley Page had pointed out, it was far too early as yet to settle down to the use of standard equipment, and the rate of development to-day was really very much greater than was being put into effect in the field. It was difficult to see how this problem was going to be met. Other countries, undoubtedly, were thinking along very different lines. The German Government was fostering a company in Germany which, by running in other countries what was practically a transport development branch, had succeeded in placing in service 150 machines. Obviously the rate of attrition and demand under such conditions must be such that progress on the technical side would be a great deal quicker than in this country, where we were still using machines which were actually put into service in 1922. As the rate of reduction of the cost of carrying passengers was so very slow, he thought the time had come when Sir Sefton Brancker should seriously consider the whole question and devise some scheme whereby a programme of research could be put into operation having for its sole object the reduction of the cost of transport by air. To refer to one or two small details, he was rather struck by the proposal to make Croydon into a very large aerodrome. He thought that a somewhat dangerous proposition. If the manufacturers and designers of machines in this country got it into their heads that they had to design a machine which could be operated at Croydon, difficulties might arise at many of the other aerodromes which it was necessary for them to use, and which were decidedly worse than the present Croydon aerodrome. One of the first duties of the International Technical Commission would be to agree upon the size of aerodrome for international use.

MR. A. E. PARNACOTT felt that aviation in this country had been practically at a standstill since the war. He thought that if only the individual had more liberty and was encouraged, machines would be forthcoming which would not require large aerodromes for landing. The danger of mechanical failure, entailing a false landing and turning turtle and crashing of the machine was rather present to the mind of the prospective user of aviation facilities. He made some suggestions for the construction of machines so as to obviate landing trouble and decrease the landing speed. He was also of opinion that more encouragement should be given to designs of machines not only suitable for carrying large loads, but suitable for individual ownership. More might be arranged to promote the production of machines due to individual initiative.

SIR SEFTON BRANCKER, in his reply, said that he thought some of the critics really agreed with him, although they tried to disguise their agreement. Captain Instone was very flattering; he had described him as an enthusiast, and had suggested what he might do if he (Sir Sefton Brancker) were not in an official position. But the fact was that if he (Sir Sefton) took on business he would probably starve within a year! Some kind things had been said about his trip to Rangoon, but he had played for safety the whole time, and he had, perhaps, the finest pilot for that sort of work that could be found in the world; also a wonderful mechanic. The only time he avoided "safety first" they proved how safe it was, and that was after being bottled up in Prague for two days by reason of snowstorms. They pushed off through South Germany in a snowstorm, and presently, being unable to see in any direction, found themselves compelled to descend. There could not have been a nastier bit of country to find a place for landing, but the landing was accomplished perfectly safely on the top of a hill, and he did not think they ran twenty feet on touching the earth. He only gave that as an indication that on the one occasion when they did not play for "safety first" they got into trouble, and even then were not in danger.

Captain Instone had mentioned the accidents to the training officers of the Air Force. In Parliamentary fashion, he would "need notice" of the question that

Captain Instone had put to him in this particular. But he would merely say that no one was deterred from learning to ride because a few people broke their necks steeplechasing. European squabbles were indeed a most awful nuisance; he would only claim that they kept him fit and busy. With regard to the Empire it would certainly be a great thing to shorten up imperial communications. Take his own case, in sixty days' leave he was practically confined to Canada and America, but with the air service fully in being a man in sixty days' leave would be able to visit Australia, even New Zealand, Burma, and South Africa.

Mr. Handley Page was a professional pessimist. He would only say, as furnishing possibly some explanation of Mr. Handley Page's point of view, that three years ago Mr. Handley Page was deeply interested in the purely transport side of aviation; to-day he had left transport and was now manufacturing aircraft. Thus he had got an entirely different outlook. With regard to his point about passenger traffic, he was afraid that the passenger traffic between London and Paris was a luxury trade. The Paris service had been running steadily since 1919; the other services were only at the most about two years old, and one could not really gather the trend of things yet. He did not think there was a real drop in passenger traffic in 1924. The decrease as compared with 1923 was due to the fact that in April and May—most important months—the traffic was interrupted by the entirely adventitious circumstance of a dispute with the pilots. He wished to emphasise that in his view the short routes, to Paris and Brussels, and even Cologne, were purely experiments, from which data and experience were to be gathered which could be applied to imperial routes. He had desired to accentuate the comparative unimportance of what was being done at present. It was the imperial communications which were going to lead to big things in air transport. In reply to further points by Mr. Handley Page, we were getting to a stage at which flying by night would be possible in winter. The process of obtaining perfect regularity was going to be a slow and difficult one, and it was really a matter of time, brains and money spent on technical development. The development of commercial aircraft was an extremely difficult problem. His own view was that the Government was being very liberal in the money it provided for experimental commercial aircraft, and he did not think that the designers could complain of Government apathy, but with one or two exceptions the people who produced aircraft would not face up to the problem because they did not see the money in it in the way of orders.

Wing-Commander Cave-Brown-Cave had put forward a very good idea, and he (Sir Sefton) would cordially extend an invitation to any member of the Society to visit Croydon, or, if an expedition were organised, he would see that there were those present who could take the visitors round to see everything.

Colonel Bristow completely forgot the Chancellor of the Exchequer, who had little sympathy with air transport. With regard to large aerodromes, there were a great many very good aerodromes in Europe, and most of the bad ones could be very easily improved.

The last speaker was certainly one of the pessimists. The answer to his point about machines turning over was that they did not turn over. He agreed with his point about individual initiative.

In conclusion he thanked the Society very heartily for the way in which his paper had been received.

THE CHAIRMAN called upon the meeting to express formally, but none the less heartily, its thanks to Sir Sefton Brancker, and the motion was carried unanimously.

MEETINGS OF THE SOCIETY.

INDIAN SECTION.

Friday afternoon, at 4.30 o'clock :—

JUNE 12.—BRIGADIER-GENERAL SIR PERCY SYKES, K.C.I.E., C.B., C.M.G., "The Heart of Asia and the Roof of the World." THE RT. HON. LORD LAMINGTON, G.C.M.G., G.C.I.E., will preside. The paper will be illustrated with Special Coloured Lantern Slides.

DOMINIONS AND COLONIES SECTION.

Thursday afternoon, at 4.30 o'clock :—

JUNE 18.—HON. W. G. A. ORMSBY-GORE, M.P., Under Secretary of State for the Colonies, "Some African Problems." THE RT. HON. J. H. THOMAS, M.P., will preside.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

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MONDAY, JUNE 8..Geographical Society, 135, New Bond Street, W. 8.30 p.m. Colonel C. H. D. Ryder, "The Demarcation of the Turco-Persian Boundary in 1914."

Chemical Industry, Society of (London Section), at the Chemical Society, Burlington House, Piccadilly, W. 8.15 p.m. Annual Meeting, Messrs. A. E. Dunstan, F. B. Thole and W. H. Thomas, "Colloidics of Petroleum."

Faraday Society and the Iron and Steel Institute, at the Institution of Civil Engineers, Great George Street, S.W. 3.30 p.m. (1) Sir Robert Hadfield, Introductory Address. (2) Mr. A. McCance, "Balance Reactions in Steel Manufacture." (3) Mr. J. B. Ferguson, "Equilibria in Systems involving Ferrous Oxide." (4) Mr. P. MacNair, "Slag Reactions." (5) Mr. T. P. Colcough, "A Study of the Reactions of the Basic Open Hearth Furnace." (6) Mr. J. H. Whiteley, "The Function of Ferric Oxide in the Acid and Basic Open Hearth Processes." (7) Mr. F. T. Sisco, "The Chemical Reactions in Basic Electric Process." (8) Mr. W. J. Rees, "The Micro-examination of Steel Making Refractories." (9) Mr. A. L. Feild, "Physico-Chemical Phenomena from Melt to Ingot."

University of London, University College, Gower Street, W.C. 5.30 p.m. Profs. A. V. Hill and J. C. Drummond, "Biochemistry. (Lecture VI.)
At King's College, Strand, W.C. 5.30 p.m. Dr. R. Dyboski, "The New Poland." (Lecture VII.)
At the London Day Training College, Southampton Row, W.C. 5.30 p.m. Dr. G. Dyson, "The Evolution of Instrumental Music." (Lecture III.)

Royal Institution, Albemarle Street, W. 5 p.m. General Monthly Meeting.

TUESDAY, JUNE 9..Anthropological Institute, 52, Upper Bedford Place, W.C. (Indian Section.) 4.30 p.m. Bishop Whitehead, "Anthropology in the Mission Field."
(Ordinary Meeting.) 8.15 p.m. Paper by Khan Bahadur Dr. J. Modi.

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C. 8.30 p.m. Air Vice-Marshal Sir Sefton Brancker, "Imperial Air Routes to India and Australia."

Zoological Society, Regent's Park, N.W. 5.30 p.m. (1) Mr. C. B. Williams, Exhibition of Cinematograph Films illustrating method of fumigating Citrus Trees in Egypt. (2) Mr. A. Gibson, Exhibition of Films showing methods of combating the European Corn borer in Canada. (3) Capt. E. W. Shann, Exhibition of Films taken on board the "Salpa" at Plymouth (4) Prof. J. P. Hill and Mr. A. Subba Rau, Exhibiton of Developmental Material of the Slender Lemur (*Loris gracilis*) recently obtained from South India (5) Mr. A. Subba Rau, "Contributions to our Knowledge of the Structure of the Placenta of Mustelidæ, Ursidæ, and Sciuridæ." (6) Prof. D. M. S. Watson, "The Structure of certain Palæoniscids and the Relationships of that Group with other Bony Fish." (7) Dr. H. H. Woollard, "The Anatomy of *Tarsius spectrum*." (8) Mr. J. R. Baker, "A Coral Reef in the New Hebrides." (9) Dr. J. Stephenson, "Oligochæta from various Regions, including those collected by the Mount Everest Expedition 1924." (10) Messrs. C. R. Narayana Rao and B. S. Ramanna, "Note on the Conus Arteriosus of some Genera of Engystomatidæ and certain Examples of *Rana* and *Bufo* (Batrachia.)"

University of London, at King's College, Strand, W.C. 5.30 p.m. Rev. J. K. Mozley, "The Doctrine of God." (Lecture III.)
At the London School of Economics, Houghton Street, Aldwych, W.C., 5 p.m., Prof. G. Cassel. "Fundamental Thoughts in Economics." (Lecture I.) Lectures II, III, IV on June 10th, 11th, 12th.

WEDNESDAY, JUNE 10..Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.
University of London, at King's College, Strand, W.C. 5.30 p.m. Mr. J. L. Evans "Economic Aspects of the Eastern Question in the Nineteenth Century."

THURSDAY, JUNE 11..Royal Society, Burlington House, Piccadilly, W. 4.30 p.m. (Croonian Lecture.) Prof. W. Magnus "Animal Posture.".
Linnean Society, Burlington House, Piccadilly, W. 5 p.m..
Historical Society, 22, Russell Square, W.C. 5 p.m, The Alexander Prize Essay.
Antiquaries, Society of, Burlington House, Piccadilly W. 8.30 p.m.
Chadwick Lecture, in the Chelsea Physic Garden, Swan Walk, Chelsea, S.W. 5.15 p.m. Sir Daniel Hall, "The Sources of the Fruit and Vegetable Supply of London."
University of London, University College, Gower Street. W.C. 5.30 p.m. Prof. E. C. Gardner, "Mazzini as Philosopher and Prophet."
At University College Hospital Medical School. 5 p.m. Dr. J. Hay, "Cardiology." (Lecture I.) (Lecture II on the 12th June.)
At King's College, Strand, W.C. 6.30 p.m. Dr. O. Vocadlo, "The Czechoslovak Republic To-day." (Lecture VIII.)

FRIDAY, JUNE 12..Institut Français du Royaume uni, 3, Cromwell Gardens, S.W. 5 p.m. M. Lafourcade "Mallarmé et les Chapelles Symbolistes."
Astronomical Society, Burlington House, Piccadilly W. 5 p.m.
Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W. 6 p.m.
Physical Society, at the Imperial College of Science and Technology, South Kensington, S.W. 5 p.m. (1) Dr. G. Temple, "Mass and Energy." (2) Messrs. E. Tyler and E. G. Richardson, "The Characteristic Curves of Liquid Jets."

Royal Institution, Albemarle Street, W. 9 p.m. Sir William Pope, "Faraday as a Chemist."

SATURDAY, JUNE 13..Institut Français du Royaume Uni, 3, Cromwell Gardens, S.W. 3 p.m. Comte Serge Fleury, "Le Paysan, Personnage Littéraire et Elément Social."
Musicians, Society of, University College, Gower Street, W.C. 6 p.m. Mr. W. Starmer, "Bells—Great and Small."

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FRIDAY, JUNE 12, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

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NEXT WEEK.

THURSDAY, JUNE 18TH, at 4.30 p.m. (Dominions and Colonies Section.) HON. W. ORMSBY-GORE, M.P., Under Secretary of State for the Colonies, "Some African Problems." THE RIGHT HON. J. H. THOMAS, M.P., late Secretary of State for the Colonies, will preside. Tea and coffee will be served in the Library from 3.45 p.m.

VISIT TO CROYDON AERODROME.

At the Ordinary Meeting held on May 6th last, when Air Vice-Marshal Sir Sefton Brancker read a paper on "Commercial Aviation," a suggestion was made that Fellows of the Society might like to visit the Aerodrome at Croydon. Sir Sefton Brancker communicated the proposal to the Air Ministry, who have intimated their readiness to receive a party of twenty Fellows at the Aerodrome on Thursday, June 25th, and a similar party on Friday, June 26th, at 3 p.m.

Fellows of the Society who desire to avail themselves of this invitation are requested to communicate at once with the Secretary of the Royal Society of Arts, John Street, Adelphi, London, W.C. 2. In doing so they should state whether they will be able to attend on either day.

The number of visitors has to be strictly limited so as to permit of those who accept the invitation being shown over the Aerodrome.

Tickets of admission will be issued in the order in which applications are received.

CASES FOR JOURNALS.

At the request of several Fellows of the Society, cases have been made for keeping the current numbers of the *Journal*. They are in red buckram, and will hold the issues for a complete year. They may be obtained post free, for *7s. 6d.* each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

TWENTY-FIRST ORDINARY MEETING.

WEDNESDAY, MAY 13TH, 1925.

(Joint Meeting of the Royal Society of Arts, the Royal Aeronautical Society and the Anglo-Batavian Society.)

MAJOR-GENERAL SIR FREDERICK SYKES, G.B.E., K.C.B., C.M.G., M.P., in the Chair.

THE CHAIRMAN said that he had very great pleasure in welcoming Mr. Van der Hoop, a pioneer in long distance flying. At the outbreak of the war, Mr. Van der Hoop was a student at the University of Amsterdam. During the war, when the Dutch Army was mobilised, he obtained a commission in that Army; after the war he became a pilot in the Royal Dutch Air Service, and for two years he flew as a pilot, *inter alia*, between Amsterdam and Croydon. The Chairman did not propose to paint the lily by endeavouring to add words of appreciation of a flight, the complete success of which recorded its own splendid history; but he wished to assure Mr. Van der Hoop and all those Dutch ladies and gentlemen in the audience that this success had been no less welcome in British aviation circles than it had been in Holland. In byegone times the whip and broom at the masthead had been the emblems of the navigation relations of our two countries. In air navigation, on the other hand, we had ever-increasing co-operation, friendship and affection.

There were a number of men present that evening who for years had been working and preaching in different capacities, but with equal zeal, on the problem which Mr. Van der Hoop had done so much to advance—the harnessing of the air to pacific purposes. Our aerial relations were established during the war, and there were many in this country who, when circumstances interned them in Holland, learnt to love it and its people for the great kindliness and hospitality which they received.

The Netherlands Government was one of the first after the war to give civil aeronautics their chance, and when the speaker visited the great aeronautical meeting at Amsterdam in August, 1919, he met more than one who had come to scoff and remained to pray. Nor had we in this country forgotten that an indispensable factor in the flight of Ross and Keith Smith to Australia was the assistance they received from the Dutch East Indies.

The Netherlands Government had afforded a practical link throughout the past six years between those who had and those who had not seen their way to join the International Convention of Air Navigation—a link without which international air transit must have tended towards a state of chaos.

We were very grateful to Mr. Van der Hoop for visiting us so soon after his great success.

The paper read was:—

THE FLIGHT TO THE NETHERLANDS EAST INDIES.

BY THOMASSEN À THUESSINK VAN DER HOOP.

The year 1924 has been characterised by the number of long flights. As a matter of fact, since the war, many people have continually tried to make long-distance flights, and the man who gave the initial start was certainly Sir Ross Smith, who made his famous flight from England to Australia in the winter of 1919-1920. In the history of aviation the year 1924 will be marked by the flight round the world, the Paris-Tokio flight by Pelletier Doisy, the Lisbon-Makao flight of the Portuguese and the flight round Australia. As one of the causes of this tendency we may regard the improvement of the machines and engines which gave the aviator a better chance of success. Another cause is certainly the attempt of several countries to make a closer link between their colonies, and this cause becomes stronger as the general economical state seems to improve.

Shortly after the war the idea was conceived of making a flight from Holland to the Dutch East Indies, and the Dutch-East-Indian Government promised a prize for the first Dutch crew who succeeded in flying to the Indian archipelago. General attention was still more drawn to this flight when Ross Smith passed the Dutch East Indies during his flight. In Holland as well as in the Indies several schemes were made both by the naval and the military flying services. Some of these had a good chance of success and elaborate preparations were made. Owing to lack of financial help and political difficulties, however, all these schemes had to be given up.

In the meantime the Dutch air-traffic developed gradually notwithstanding the unfavourable economical conditions, and steadily the number of passengers grew as well as the amount of goods and mails transported. At the same time the number of airlines increased.

In this way it was evident that public attention was drawn to air traffic in the Indies as well. The vast Indian archipelago covers a distance equal to that from Portugal right eastwards to Siberia, and is a country of immense wealth with more or less unsatisfactory means of transport and with a climate which makes it specially adapted for air-traffic.

The aeroplanes developed in proportion to the air-traffic. At first converted military machines were used, with a very small loading capacity and a high petrol consumption that made air-traffic anything but a paying proposition. Moreover, there was little comfort for the passengers. The Fokker works, which had gone very seriously into the construction of traffic machines, started with their famous series, F-machines. The first of these, used by the K.L.M., was the F. II, a four-passenger carrying machine with the same engine as had been used formerly in the military machines which could only take two passengers. A new type again was the F. III, which is still used by the K.L.M. and takes 5 passengers.

As a result of the increase in the number of passengers the demand rose for larger machines with a capacity of 6 or 8 passengers and in the end of 1922 Fokker appeared on the market with the F.V, with a Rolls-Royce engine of 360 h.p. The opinion of Fokker himself was, that this machine would be the very type for the use on an airline between Holland and the Indies. This remark resuscitated the idea of flying to Batavia. Such a flight would do a lot of propaganda for air-traffic in general, and particularly for the projected airlines in India. At the same time rumours went that England had the prospect of opening an airline from England to the British colonies and eventually to Australia. As this line should go *via* the Dutch East Indies, the Dutch saw the possibility of forming a link in this connexion.

All these considerations led to the foundation of the Holland-India Flight Committee in the beginning of 1923. General Snyders, the ex-commander-in-chief of the Dutch military and naval forces, was appointed chairman and many leading business people as well as shipping firms, bankers, the Fokker-works, the K.L.M. and the Royal Dutch Aero-Club lent their support. The object of the committee was to carry on propaganda and to study the possibilities of air-connexions to and in the Indies.

At once several difficulties arose. In the first place the Dutch as well as the Indian Government withdrew any financial support as a result of the general tendency to economise as much as possible. Thus all the money required had to be supplied by industrial and mercantile concerns, which proved rather difficult in that period. Secondly the F.V machine mentioned before did not give the results expected.

The construction of a new type, the F. VII was directly taken in hand, but this machine could not be ready and thoroughly tested before the first of April, 1924, the date previously fixed for the departure.

It was proposed to use instead of a commercial machine a military plane, but this gave rise to many objections. Although a military machine was faster, it would give less room and comfort, which would make it necessary to do the flight with only one pilot and one mechanic instead of two pilots. Moreover, it would be impossible to take enough big spare parts in a military machine, such as wheels and a spare propeller. The main objection, however was, that the flight was undertaken on a purely commercial basis and propaganda would be much less effective if a military machine were used instead of a commercial plane.

Therefore, it was decided to postpone the flight till October 1924, on which date the F. VII might be expected to have passed all her tests.

It was necessary to fix the start either on the first of April or on the first of October, owing to the atmospheric conditions in the Indies. As you know, there is a very heavy rainfall in the Dutch Indies as well as in British India during the rain-monsoon. This rain affects the visibility very much and is very bad for the machine in general and especially for the propeller. Flying in such weather is hardly possible. When one passes over high mountains the clouds may even come down right down to the ground, a cause which gave many difficulties to Ross Smith during his flight over Burma.

To be sure, these rains are generally very local, so that it is possible to fly round them, but the main trouble is, that the landing grounds get wet and soft, or are even flooded so that a landing may be dangerous. When the air route to India is once well organised and all the aerodromes are drained properly, this difficulty will be overcome, but this can only be in the future. Often one has to land on racecourses or fields which one here in Europe would call forced-landing grounds and which are absolutely useless during the rain-monsoon.

Hence it was necessary to fly during the dry monsoon, but the difficulty was that the monsoons in the British and the Dutch Indies are exactly reverse; that is to say, in the British Indies the wet monsoon takes place during July and August, and in the Dutch Indies this is the time of the dry monsoon. Therefore, the best time to do this flight is during the turning times, either in April or in October.

The machine, the F. VII, was finished in the early spring of 1924, and was used by the K.L.M. on the Amsterdam-London line for two months, during which time it did 120 hours. All this time Flight-Lieutenant van Weerden Poelman and myself flew the machine, so that we had ample opportunities to familiarise ourselves with it. The F. VII gave very good results. It was a large monoplane with wooden wings covered with three-ply of 60 feet width and a fuselage of welded steel tubes of 42 feet length. The pilot's cockpit gave ample room and was arranged for double control. In this way it was very easy to relieve each other. From the cockpit a small door led to the very roomy cabin where the mechanic was seated and many spare parts were stored. Behind the cabin was the lavatory and a luggage compartment which was used as a storage room for small spare parts and tools. All we wanted was nicely stored and ready for use. The circumstance that the pilots could relieve each other easily and the stand-by pilot could go to the cabin to rest a while, or eat or enter the data in the log-book or study the different maps at ease contributed much to diminishing fatigue and increasing safety. As a rule we relieved each other every other hour.

During the month of September the machine was taken out of the service and made ready for the flight. A new engine, which had been tested for twenty hours was fitted; the tank capacity was increased from 180 to 220 gallons which was sufficient for a non-stop flight of ten and a half hours. Much care was given to the cooling.

With previous long flights in the tropic climate much difficulty was caused by the overheating of the engine; therefore, we decided to increase the cooling surface by 50% by fitting a second radiator. During the flight this proved to be absolutely sufficient, but one must not forget that we had rather cool weather and that during the summer, especially in Mesopotamia and Persia, the heat may be intense.

One of the greatest difficulties in a flight like this is to keep down the weight of the machine. The maximum weight permissible in Europe for the F. VII is 7600 lbs. In tropical climates, however, the lift of the wing is much less, the air being warmer and less dense. At the same time the propeller-thrust is decreased as well as the engine power. Moreover, the aerodromes on our route were often small and bad, and a bad start might result in a serious accident, and a small total weight was, therefore, necessary. The increasing of the tank capacity and radiator was in direct contradiction to this, as well as the large amount of spare parts and other implements which we had to take with us. All these parts were weighed out and things which were not absolutely indispensable removed. For hours and hours the K.L.M. technical staff sat bent over their desks calculating and calculating, with the result that the total weight of the machine with full tanks amounted in the end to 7200 lbs. Thanks to this small total weight we made a good start from the different bad grounds with an engine of only 380 h.p. using 19 gallons of petrol an hour.

During the time the F. VII was used on the London line, it was fitted with wireless telegraphy and telephony, which gave always good results. The number of wireless stations on the Indian route being very few we should not have had much use for the wireless installation, and as the weight of this installation was rather important, we decided to remove it.

During the preparations for the flight one of the principal points was the collecting of details of the weather, the landing grounds, and the necessary maps. For the greater part we used maps on the one million scale completed with detail-maps of the aerodromes on a bigger scale. Perhaps the scale of the map may seem small to you but it proved to be absolutely sufficient and gave the advantage that the very long map was easy to handle and maps on a small scale give a better view in general. The different maps were joined together in long rolls and placed in front of the pilots. Further a compass of very high quality was fitted.

As the success of the flight depended to a great extent on the petrol and oil these had been sent to all the landing grounds. In this way we were always sure to find an ample supply of good quality. For security several spare tyres and propellers were sent along the route to some places, but happily we did not want them, as the original propeller and tyres are still fitted on the machine and may be used for a long time yet.

After all these careful and minute preparations the machine was ready near the end of September and we were able to start from Schiphol, the Amsterdam aerodrome which was crowded with people to see us off. The weather was good and pretty clear but we met with a slight head-wind. Flying over the town and the docks of Amsterdam, the numerous liners bade us a farewell by blowing their whistles. We went onwards over Soesterberg, the military aerodrome, Deventer and past the German frontier. This trip over the monotonous plains of Germany was rather uninteresting although the sight of the big towns of Hanover and Dresden was a pleasant spectacle. We relieved each other regularly and the time passed quickly. At Dresden we reached the Elbe which we followed up between the beautiful mountains until we were over the plain of Bohemia. In the afternoon we reached Prague, where we found a very good aerodrome with large big hangars and where the Chec authorities gave us a very warm welcome.

It was our intention to start next morning as early as possible, but as we wanted first to see the weather reports, and as it took rather a long time before these were received, we were delayed in our start. The scenery on the second day was much finer than on the first. Over the hills of Bohemia, where the clouds on some places were hanging right down on the tops, we made for the Danube and followed this river, which flows through a vast plain, offering many good places for a forced landing.

At sunset we reached Belgrade, where the lights had already been lit, and very good landing-lights marked the aerodrome.

Our first care was for the machine, and I spent about one and a half hours in the small local telegraph-office. The telegram, which cost me so much trouble arrived three days later in Amsterdam.

That night we passed in a small hotel in the vicinity of the aerodrome, enjoying a pleasant country-wine and a real Zitano band.

Thus for the first two days of our flight we carried out the scheduled program. Alas, the third day was to prove fatal.

Our original object was to follow the Danube from Belgrade through the Iron Gates over Roumania and the High Balkans to Constantinople. The people in Belgrade, however, advised us not to go through the Iron gates owing to the bad weather, and we chose a southern route over Bulgaria. At first we followed a small river through the valley up to Nish, and thence eastward over the mountains. We kept at a fairly good height over this part of our trip, but we met unfortunately with a strong wind and did not make enough headway. So we decided to come down and try to find protection by the mountains. The railway, which formed our landmark, climbed higher and higher and the cleft we passed through grew narrower and narrower. In the end we came upon a point where this cleft suddenly made a sharp turn, so that we lost our view ahead. In the case of this cleft continuing behind the turn there would not be any danger, but as it might close up suddenly, and the railway might disappear in a tunnel, we should have run dead against the mountain walls with our machine, which could climb only slowly. I did not dare to take that risk and made a sharp left hand turn and we missed the mountain wall by the skin of our teeth, and flew back to gain some height. After that we went onward high over the mountains, and the dangerous spot, down to the valley of the lately so ill-famed Sofia.

We saw a big aerodrome with great hangars and we looked down on the fine cathedral which has just been blown up. Then mountains appeared again with high cliffs and deep clefts. We had just left this landscape and were flying over plain ground of the bed of the Maritza when all at once we met with serious engine trouble.

Up till that moment the engine had being running splendidly. When a few miles from the small town of Philippopel we saw to our astonishment the thermometer rise quickly and the temperature of the cooling water rose rapidly to boiling point. Gradually the number of engine revolutions decreased. I understood that something serious had happened and I looked for a piece of ground where we could land. After some pops of the engine the roar stopped altogether and in a dead silence we glided downwards. I had just time enough to do a sharp S-turn so as to come within reach of a small meadow. In this way we hoped to bring down the machine nicely, but all at once we heard a terrific bounce of the wheel which came into contact with the ground. Slowly the machine rolled on, bouncing and bouncing, and inclined more and more to the right, so that in the end the wing-tip touched the ground. The machine made a quick turn and came to a stand-still. There was nothing for us but to get out, to light the traditional cigarette and estimate the damage done.

This turned out to be more than we had expected. The engine seemed to be damaged by overheating beyond repair. Moreover, the ground where we had landed and which looked from the air like a meadow, had formerly been used as a ricefield ; such fields are in Bulgaria artificially irrigated in the same way as is done in the Indies. Therefore a lot of small dikes of about one feet high had been erected at short distances from each other. During our landing we had touched not less than nine of these dikes with the result that the right hand wheel of the undercarriage had given way and the under-carriage itself had been seriously damaged. The very first thing we had to do was to try to find some people. Many countrymen came up to the machine directly after the landing, but nobody understood any of the western languages. Fortunately after some time a schoolmaster came along, who understood a bit of German. He led me to the nearest telephone office on the railway, which was in charge of a Bulgarian farmer. Unhappily the telephone apparatus had been sealed and was not allowed to be used by civilians. It was impossible for me to make myself understood, but fortunately there is a language, which is understood anywhere. I was not in possession of Bulgarian money, but we had taken with us some sovereigns in case of emergency. I succeeded in getting rid of the schoolmaster for a short time and produced a gold piece. The Bulgarian hereupon drew a terrific knife which scared me as I thought that he would instantly execute me for trying to bribe an official, but the good fellow had only taken up this weapon to break the seal of the telephone. So the line was free in the end, but the result was poor. After many difficulties I got into connection with Philippopel and I was told not to leave the machine before the chief policeman of the district himself had arrived to inspect our papers. So I returned to the wrecked machine and the three of us waited patiently for what would happen next.

About nine o'clock in the evening three people disguised as gentlemen turned up out of the dark. One of them seemed to be the afore-mentioned authority.

They looked at our papers without understanding anything of them and after that were going away again. I asked if they could not take us to town but it seemed they had come down with a motor lorry along the railway-track, and the loading capacity of this vehicle seemed to be so small that they had to refuse. The policeman took our telegrams with him, which were not sent away before the next day. Not without some joy I heard later on that the lorry had broken down on the way back, and that the policeman with his two assistants had had to walk all the way down to Philippopel in pitch darkness.

We tried to make the best of it. By the light of the moon and of a small paraffin lamp we organised with some military people and farmers a wonderful nightfeast. We gave the Bulgarian people some of our Dutch cigars, which they seemed to enjoy very much, as well as Dutch cabbages and sausages in tins. We on our side tasted for the first time Bulgarian land-wine and tried to enjoy the Bulgarian music of a bag-pipe. After the lamp went out for lack of paraffin and the bag-pipe had stopped we stretched ourselves in the comfortable cabin of our modern traffic machine. However comfortable the cabin may be for passengers it is not exactly fit for a sleeping compartment under circumstances like these.

In the afternoon of the following day the Dutch consul from Philippopel arrived in a Ford car and with this vehicle we went along over the very bad roads to town.

For more than a week we were waiting in Philippopel. Our position was far from pleasant. There was an aerodrome near Sofia, about eighty miles off, but it would have been impossible to transport the machine thither owing to the very bad state of the roads. At any moment the Bulgarian winter with heavy snowfalls might make its entrance and it was impossible to postpone our arrival in India too long for fear of the monsoon. I feared, therefore, that it would be impossible to continue the flight then and that we should be obliged to make a new attempt next spring.

After a week of waiting, telegraphing and writing letters the chief of the technical service of the K.L.M. arrived in Philippopel to make an investigation. You can imagine our relief when he told us that he thought the machine could be repaired on the spot within a month's time. At once the Fokker-factory started to make the necessary parts for the undercarriage, and the illustrated paper *Het Leven* gave us a new engine. From Holland as well as from the Indies financial support came, and so the prospect seemed to us much more hopeful than we had dared to expect. In the meantime we started to make the necessary preparations for the repair of the machine. The fuselage was lifted, the old undercarriage removed and the engine, with the help of a crane of our own construction, taken out of the machine. After that we waited for the arrival of the new engine, the spare parts and the mechanics of the Fokker factory.

To be waiting for several days in a town like Philippopel is not altogether cheerful. Although this town has about 120,000 inhabitants the life is not very comfortable. Fifty years ago the town was still Turkish, and half the population consists of Turks. There is practically no pavement, the hotels as well as the food are bad. The water supply was just enough to enable us to clean our teeth in the morning. Taking a bath in Bulgaria is regarded as unnecessarily luxurious. The mail arrived slowly and at long intervals. To get into telephonic connexion with other towns is practically impossible and the telegraph office works as badly as the telephone. Only very few people speak some French or German. A very dirty picture show and an underground cave which was named a cabaret were all the places of entertainment the town could afford. So there was not much more to be done but to rise late in the morning, drink a lot of Turkish liquor and take a good lunch time. In the afternoon we drank Sliwowitch, a kind of brandy from the country. After that we had what was supposed to be a dinner, and at an early hour we went to bed again.

At last, after long waiting, three mechanics arrived from Holland with the engine and spare parts about the end of October. They had met with some difficulties on the Servian-Bulgarian frontier as the Serbs obviously feared that the Bulgarians would certainly try to start a war with all this valuable material.

At once we started to work. The engine was moved on a tractor along the bad roads up to the machine, and the rest of the material was loaded on carts drawn by oxen. For five days we worked very hard. We had to motor about 18 miles every morning from the town to the machine, and the roads had become very bad owing to the heavy rainfall. Often we had to use all our forces to get along with the car and dig it out of the mud. Moreover, it was not a very easy task to do the repair works in rain and mud. Nevertheless everything was completed by the evening of the first of November and the machine was again ready to start. The engine had been tested and proved O.K. and we had found a piece of ground in the neighbourhood which was just long enough to start from. The road which led to this ground had been made smooth so that it was possible to have the machine taxied along.

In the small hours of the morning of the 2nd November all of us went up to the field. It was a fine and clear day; and the first snow was visible on the tops of the Balkan and Rodopo-mountains. The start was far from easy. In fact the field was very small and situated in such a way that we had to start with a feeble wind in the back. Happily everything went splendidly, although now, when I come to think of it, I feel that we had a narrow escape.

You can hardly imagine our joy and relief as the wheels of the machine left the ground and we could bid farewell to Bulgaria and continue our journey to the far-east.

On that day we did not fly much. We went over the Bulgarian plain and passed Adrianople, an old Turkish town with a beautiful Mosque. Over desolate country on we went and within a short time we could see the Sea of Marmora and the Anatolian coast. The sight of that continent on which we had to pass the next few weeks was very cheerful to us who had been held up so long in Bulgaria. In the afternoon the wheels of the machine struck the ground of San Stefano aerodrome near Constantinople. The field itself was good enough but there was only one very small hangar, and it was impossible for the F. VII to be brought inside. The whole lighting system consisted of one small paraffin lamp, and owing to the danger of fire we decided not to work on the machine till the next morning.

The Dutch colony assisted at our landing, but to be sure of ourselves the next day we did not go into the town and slept at San Stefano in a small hotel giving a beautiful view of the moonlit Sea of Marmora.

The very first thing to do next morning was to inspect the engine and the machine. At first the engine gave some trouble as a result of bad plugs, and this caused us to start pretty late.

We crossed the Sea of Marmora and the sight of the old city of Stambul with its many mosques and minarets, of the blue water of the sea of Marmora and the Bosphorus and the Golden Horn with its ships we are not likely to forget.

Along the Princes-Iles, which made a beautiful contrast with the clear water, we made for Asia Minor. Here the scenery changed. The mountains were not very high but still dangerous enough in case of a forced landing. Our first landmark was formed by a big lake. Then we reached the Baghdad railway, which we followed up to Eski Sher, a bad looking place where the Angora railway leaves the main track. Here again the landscape changed, as we arrived in a vast sandy plain. The whole vegetation consisted of dry and short grass. This plain was bordered by naked hills on the north, as well as on the South, and the only villages we saw were not more than a collection of small huts. A forced landing on this ground would be easy, but to get the necessary help would have given much more difficulty than in Philippopel.

In the meantime the wind had increased and we only made slow headway. Behind us the sun went lower and lower and the sandy hills showed themselves in a red hue. Then the sun set, and still Angora was out of sight. At last we saw far away against the hills the lights of the town. We knew that the aerodrome was large and rough and landing was only possible in the middle. Unfortunately we could see in the dusk that a herd stood on the very spot where we had to land. Therefore we had to make our landing as short as possible, and we turned right over the chimney pipes of a factory into the field. All at once I heard a very strange noise, after which some undistinguishable object rose in the dark on the left of the fuselage. Next moment we heard a loud bang against the lefthand wing. We landed safely, however, and now the strange noise proved to have been caused by a telegraph wire which had wound itself several times round the propeller. while the wing had struck a wind indicator which shows the pilot the wind-direction on landing. Fortunately, the damage was not very important. We only had to glue a piece of threeply-wood on to the wing.

Angora, the new capital of Turkey, is a very poor and small place which stands quite isolated on the bare plateau of central Anatolia. The flight from there to our next stop, Aleppo, proved to be very interesting. At first we went for hours and hours over the lonely desert of Anatolia and passed a large salt-lake with salt precipitation along the banks. Here and there naked cliffs rose high up, and far away in the east a single snow covered peak contrasted with the blue sky. After having flown for several hours on compass course we again found the Baghdad railway in the south of Anatolia, and reached the Taurus mountains with their steep cliffs which rise as high as 10,000 feet. These mountains were too high to fly over with our heavy machine, so that we were forced to fly eastward following the railway a long time, down to the Cilician gates. Like a narrow street this pass runs between the mountains of the Taurus and Anti-Taurus, and on our left and right the peaks rose high above us. Underneath there was only the narrow cleft through which a small stream forced its way and where the railway disappeared from one tunnel into the other. We shall never forget this wonderful scenery, but in case of a forced landing the good old F. VII would have met with a terrible end. A French aviator from Aleppo told me later on how to make the best of a forced landing in such a situation. According to him one must not try to land on the bottom of the cleft but make a sideslip with the machine till the wing strikes the mountain-side. The wing crashes in this way on the impact and the machine rolls itself up more or less and in doing so one has a good chance of saving oneself. This may appear to be the safest way but we were glad that it was not necessary to try the experiment.

All at once the cleft enlarged itself and six large eagles came to meet us, soaring quietly by way of seeing us off from the mountains, and in front of us the great plain of Adana stretched itself out, with the Mediterranean in the background. We came down from about six thousand feet to some hundreds of feet, crossed the gulf of Alexandretta and entered Syria. After a short flight over a low range Aleppo was in sight.

We landed on the excellent aerodrome, where we were received by the French pilots, who gave us all the necessary help.

Over the desert we went from Aleppo to the Euphrates which looks from the air like an irregular brown line. We followed this river and saw from time to time a small village and some French aerodromes. Some caravans moved slowly underneath—a little donkey in front followed by a long row of camels. About noon the people tried to fine shelter under their low black tents, whereas the camels kept standing round in the sunshine.

Gradually we came to Irac, the British mandate. After some time we left the Euphrates and made eastward to the Tigris. A squadron of English machines flew past us and we went over Baghdad, a picturesque Eastern town with many high palm trees, and landed on the south side on the well organised R.A.F. aerodrome. Here again we were received very cordially and found magnificent technical help.

Our next aerodrome was Basra in the South of Irac, near the Persian Gulf, but having the wind behind we decided to continue as far as Bushir on the Persian coast. In this part of the world people say the Paradise must once have been, and the country is rich of recollections of the Bible. First we went over the ruins of Babylon. A large circular wall and some square heaps of stones are all that is left of this once so famous town. Later on we saw, far in the distance, the old Sun-temple of Ur of the Chaldeans, the residence of Abraham.

The Persian coast gave us an impression of vast, sandy plains and desolate cliffs. We landed first at Bushir and went from there to Bandar Abbas, where the few Englishmen present gave us a warm reception. The bare coast is scarcely inhabited and the small villages have no connexion whatever with the inland country.

The third aerodrome on the Persian coast was Carbar, whereto we had also sent petrol supplies, but thanks to a favourable wind we passed it, making in this way a non-stop flight from Bandar Abbas to Karachi in British India. In general we had met with very good weather up till then but near Charbar a sandstorm was blowing. Fortunately the wind-direction was from the coast so that we could fly above it while following up the coastline. If one should, however, be forced to fly through such a storm, which sweeps up the sand dust to a height of several miles; it would prove to be very difficult and disagreeable, and at the same time very bad for the engine.

We passed over British India from Karachi to Calcutta along the different aerodromes, made by the R.A.F. in that part of the country along the Indus and Ganges. Here again we could pass the aerodrome at Multan, where we should have landed originally, and made directly for Ambala. From there we flew to Allahabad and next to Calcutta. A shorter way would have been to fly from Karachi due East to Agra, but in this way one passes the very desolate Indian desert where it would be impossible to get any help in case of a forced landing, the more so, as there are no aerodromes. So we preferred to go round by the northern route. The aerodromes in this part were very good, and we always found very hearty hospitality and valuable help at the R.A.F.

Very interesting indeed was the flight along the Ganges, and over the towns of Delhi, Agra and Allahabad. At Agra we passed right over the Taj Mahal, the mausoleum erected in 1625 by Shah Jehan as a memorial to his wife. It is one of the most beautiful buildings in the whole of India and with its white marble towers it shows in very striking contrast against the dark green of the surrounding parks.

Past Calcutta we flew over the Ganges delta, cut by many river-arms and all covered with ricefields, moors and woods In this way we reached Burma along the coast of Bengal, and we found a sudden change in the aspect of the country. Instead of the very wide plains of the Punjab where it was possible to find some good forced landing grounds we found here high mountains covered with forests frequented by tigers and other big-game. Here and there one finds along the coast low-lying moors and ricefields but elsewhere the mountains continue right up to the sea. As a matter of fact one may safely say that from Calcutta to Batavia there are no forced landing grounds at all. A forced landing in the forest would not only be dangerous as regards the landing itself, but even in the case of a good landing the crew would be absolutely helpless and would only have a very small chance of seeing the inhabitated world again.

First we landed in Akyab and from there made for Rangoon. Here we had a very narrow escape. Flying over the town the aerodrome turned out to be a small racecourse, surrounded with high trees and houses, so that the landing would be dangerous and it would be impossible to start again, with a heavy machine like ours. Moreover it was impossible to continue to Bangkok, as we had hoped first to do; owing to the strong headwind, the distance was too great to cover in a non-stop flight. We were at our wits' ends and decided to fly back to Akyab and to try to fit another tank so that it would be possible for us to do a non-stop flight from Akyab to Bangkok. Fortunately we discovered in the end at some distance from the town a racecourse under construction which offered us just enough room to land upon.

All ended well and the next day we had the obstacles removed so that we might start again safely.

In Rangoon we had an opportunity of seeing the famous Pagoda, one of the largest Buddhist temples in the world. The pagoda itself is made of stone, bell-shaped about 50 metres high, standing on the top of a hill, and all gilded. Large covered staircases lead to the surrounding terraces where ever so many small temples have been erected with picturesque roofs and richly decorated.

Crossing the mountains and jungles we went from Burma to Bangkok, the temple-town, the capital of Siam, the Venice of the East. From there along the east coast of the Malay Peninsula to Sengora, a small Siamese town, with an aerodrome not more than 320 yards long. On our last trip the engine had not been running quite satisfactorily and in Sengora we found several valves leaking so that we decided to overhaul the engine. For two days we worked on the sandy aerodrome in the glaring sun. After that we continued happily again, flew over the Malay Peninsula, past Penang and had to cross the only large stretch of sea of the whole flight, the Street of Malacca, which separated us from the Dutch East Indies. A Dutch steamer lay waiting for us at the Malacca coast, to provide help if wanted. We were accompanied by seaplanes of the Dutch navy, up to the coast of Sumatra, and only a few hours after having left Malacca we landed safely on the racecourse in Medan, where we found an unforgettable and hearty welcome.

The next flight led for eight hours over the vast jungles and marshes of the coast of Sumatra to the small town of Muntok. From there we again followed Sumatra to Street Sunda between the islands of Sumatra and Java, and there we were escorted by seaplanes again and so we reached Java, all safely, and continued in the middle of squadrons of the Indian military air force to Batavia, our longed for goal.

Before ending I wish to express here my sincere gratitude to the English authorities and the R.A.F. in particular for all their kind and useful help and hearty hospitality which we always met with during the preparations for this flight as well as during the flight itself.

DISCUSSION.

SIR WALTER TOWNLEY, K.C.M.G., said he had listened with the closest interest to the graphic description of the flight which had been given by the lecturer. He had told his story in a most interesting way, and had given us a good idea of how things are done in these days. What he had to say was of great and particular interest to the speaker, because he travelled over one of the countries described—Mesopotamia—several years ago. He did not, however, travel as the lecturer did. While he was on a pony which was with difficulty persuaded into a feeble canter, Mr. Van der Hoop travelled with the celerity of an airman. It took the speaker twelve days to cover the distance which the aeroplane covered in two days. They were twelve very enjoyable days, but they must have been even more enjoyable for Mr. Van der Hoop because he missed an experience which the speaker had of being held up by brigands. Incidentally, he might mention an occasion in Constantinople when a gentleman doubted that there were actually brigands in the country. In support of his statement, Sir Walter told the man that he himself had been held up by them. To this the man replied, "They never ought to have let you through."

The Chairman had spoken of the hospitality and kindness which was shown to our prisoners of war in Holland. He (Sir Walter) was Minister in Holland at the time and knew something about it. He could endorse every word that the Chairman had said. After being starved and ill-treated in Germany for two and three years our men came out of their long incarceration and found that they received the utmost kindness and attention from all. He would like to say too—for he heard it on all sides—our men also behaved very well. Coming out of prison after three years they carried themselves with that jaunty air that one expects and finds in the English soldier. We must not overlook the importance of the position that flying was going to take in the business world in the near future. The fact that aviation was bringing enormous distances near home was a great thing for trade and trade interests. Manufacturers and other business men would be able to get parcels, samples and letters much more speedily and satisfactorily than was possible at present. With the development of flying there would be a revolution in trade. Flights such as that made by Mr. Van der Hoop helped this object, and he hoped that these enterprises would bear fruit at an early date. He had never been up in the air himself, but he admired those who did fly. All present would remember the wonderful flight from India made by Sir Sefton Brancker, who had spoken on the subject in that room only a week ago. If postal communication could be speeded up by aviation we should see one of the great developments of aerial transport. He congratulated Mr. Van der Hoop for helping to blaze the trail.

MR. F. C. STOOP desired to express, on behalf of the Dutch Colony, their thanks to Mr. Van der Hoop for coming to tell of his experience, and to congratulate him on the advance he has made in the progress of flying.

MR. L. H. KIEK desired to pay his tribute of admiration and respect to one of the pioneers of aviation. Pioneers were not national, but international. If he might venture to address Mr. Van der Hoop as a business man and layman, he might claim kinship with him. In the first place because he was once one of his countrymen—though now he was a countryman of the Chairman's, and secondly because he had always taken a theoretical and practical interest in aviation. He, too, had been something of a pioneer for he made a flight through South America five years ago, when flying was not what it is to-day. In spite of this, he had to make few forced landings. The pilot of the aeroplane was Major Shirley Kingsley, an intrepid, skilful, bold, yet cautious pilot. They had many adventures and met with a few hostile receptions. They were in a country where no aeroplane had been seen before. In spite of this they obtained much pleasure and satisfaction from the trip. Aviation saved the business man a great deal of time. Rapid flying was approaching a stage when it could be demonstrated to be a commercial and valuable proposition. He (the speaker) happened to be in Amsterdam when Mr. Van der Hoop was compelled to make a forced landing. There was general dismay among the people in the city and some faint hearts thought that the whole flight was a great fiasco. Knowing what he did about aviation he tried to encourage the faint hearted and told them that a forced landing was merely an incident in such a flight. During the speaker's flight in South America the people helped him greatly. On one occasion they prepared a landing ground, but overlooked a ditch. The result was that they found themselves on their noses with the propeller in the ditch. The propeller was broken, so a council of war was held in which the natives joined. They received many suggestions and one was that they should go to the prison. They did not at first see the connection, but they were told that the carpenters at the gaol were very clever fellows. Consequently they unscrewed the propeller and took it to the prison. In one day a new blade was dovetailed in so well that you could not tell it from the old—except that it was not so well varnished. As a matter of fact, the propeller was now all that is left of the aeroplane, and the speaker still had it in his possession. That only went to show that resource and aviation seem to go together. In conclusion, he thanked Mr. Van der Hoop and wished him a continuance of that career which he has inaugurated so brilliantly.

CAPTAIN LEONARD F. PLUGGE desired to add his tribute of admiration to what had already been said. Mr. Van der Hoop had mentioned that he discarded his wireless installation, and the speaker would like to ask if during the course of his wonderful flight he did not feel the necessity for it. He travelled over many wild places where it would have been impossible to obtain assistance, and as there were R.A.F. stations with transmitters, did he not think it would have been safer to carry it? If he had met with an accident in some of the places which he passed it would have meant delay and hardship.

THE CHAIRMAN (SIR FREDERICK SYKES) also desired to congratulate Mr. Van der Hoop on his lecture. It was very remarkable to hear it given in such excellent

English. He also thanked the lecturer for showing the beautiful photographs which had been seen that evening. Some of them had seen the scenes before—but not from the same angle as that from which these photographs were taken. Mr. Van der Hoop had said that he had only two hitches in fifty-four days. He would like the lecturer to state the exact number of hours that were spent in actual flying. After hearing a lecture of this sort one wondered why more people did not take to aviation. It was a splendid adventure, and adventure was good for everyone, as it encouraged self-help and resource. The Dutch had always given great assistance to aviation. At the end of the war the National Air Convention was signed in Paris. That Convention was the basis of international flying, and the Dutch Government were of great assistance in helping to put it forward. Anyone who had anything to do with the air realised the great difficulties of international aviation—such as wireless, meteorology, and telephones. It was difficult nationally, but let them imagine the problem internationally! Such flights as Mr. Van der Hoop's helped to show the difficulties. There was a tremendous future for aviation, for several reasons. Firstly, because the steamship and train had come to the economic limits of speed. For instance, ships could only pass through the Suez Canal at a certain rate. Both ships and trains could only carry certain loads at certain speeds. The aeroplane was an instrument to alter that—the only instrument which could do so. We had got to go in the air if we were going to close up the Empire and other countries of the world. Why not do it? It was comparatively cheap. He (the Chairman) went on his honeymoon by air and he commended it to all who thought of embarking on an adventure of that sort. He congratulated Mr. Van der Hoop and urged him to undertake a fresh tour. Might he have the same success in the future as in the past!

MR. VAN DER HOOP, in reply to the discussion, said he was glad that the question had been asked about the wireless. He would like to say that he was a great believer in wireless. He had a crystal set, a one-valve set, a two-valve set, and in India a six-valve set. During this flight he was flying a very heavy aeroplane, and for this reason the weight of the wireless set was not worth the use to which it might be put. It was true he might have sent out an S.O.S., but he did not think that wireless would have been of much use to him during this flight, owing to lack of ground-stations in most countries he flew over. The Chairman had asked how many hours they were flying. The number was 127. Flying day and night he thought one could reach Batavia in six or seven days. That, of course, would be for a mail service and not for passengers. You could not do the trip so quickly at present, but later on, with organisation, it would be possible.

CORRESPONDENCE.

WANTED A WEMBLEY COIN.

A British *Empire* Exhibition without an *Imperial* official language, and an Imperial coinage is an anachronism, if not a farce. In the discussion on Lord Stevenson's paper, "The British Empire Exhibition," reported in the *Journal of the Royal Society of Arts*, May 22nd, 1925, Mr. H. A. F. Lindsay, C.B.E., I.C.S., remarked that "The merchant thought very largely in sixteenths or thirty-seconds of a penny."

As a matter of fact, no Canadian merchant has ever thought or could ever think in terms of any such clumsy fraction. Whether he speaks English or French or any other of the forty languages in which people both worship and do business in Toronto, he cannot multiply or divide by twelve (12). Why should he adopt such a foolish and confusing mental habit, which shows a singular inaptitude of means to ends? As regards such simple matters as coinage and print, "no race," says Sir Arthur Helps, "can be more contemptibly imitative and *conservative of wrong* as we are." One-thirty-second of a penny is ⅛ of a farthing or .125 farthings. No alteration of our coinage is necessary if the antiquated and idiotic pence table were abolished, and calculation by farthings substituted.

In last year's Wembley Exhibition there was not a single clerk who could explain to his customers how much profit he could make on a yard of ribbon supposing he could be induced to buy such merchandise. Surely ⅛ is a simpler fraction than $\frac{1}{32}$.

If Lord Stevenson will give us a 10-farthing or 2½d. nickel coin for use within the Exhibition, it will soon become universal all over the Empire. The spectacle of traders, purchasers, banker's clerks and omnibus conductors carting about huge bags of dirty copper coinage and spreading disease from hand to hand, is not an edifying one. Coppers to the value of 2½d. can be washed when you wash your hands, but not more than this. If Lord Stevenson can help us in this respect it will be a great advertisement for the Exhibition, and induce many to spend their spare silver there. The bribe of an extra halfpenny (5 nickels=5 x 2½= 12½=1s.) change for every shilling spent, would attract thousands, and future generations of school children would rise up and call him blessed.

(10 farthings=1 nickel, 10 nickels=1 florin, 10 florins=£1.)

A. DEANE BUTCHER.

3, St. Stephen's Road,
Ealing, W.13.

OBITUARY.

PHILIP M. JUSTICE.—The Society has lost a Fellow of very old standing by the death of Mr. Philip M. Justice, which took place at Hastings on May 4th in his seventy-first year. He was elected in 1881, and took part in several discussions on papers connected with patent law reform. He started in practice as a Patent-agent in 1878, in 1882 he became a Fellow of the Chartered Institute of Patent Agents, and was President of the Institute from 1901-3. He retired from business in 1917.

NOTES ON BOOKS.

METALLURGY AND ITS INFLUENCE ON MODERN PROGRESS. An Address Delivered before the Oxford University Junior Scientific Club by Sir Robert A. Hadfield, Bt., D.Sc., D.Met., F.R.S., F.I.C., M.Inst.C.E. London: Chapman and Hall, Ltd.

No living person, probably, is better qualified than Sir Robert Hadfield to deliver an address of this kind on his chosen subject, and the reader whose interests incline in this direction need have no fear of being disappointed in the present instance.

Appropriately enough, having regard to the purpose for which the address was composed, Sir Robert is at first concerned especially with Oxford and its men of science in former and modern times. Passing on, by way of a survey of the progress of Chemistry in general (to read which is to become conscious once more of the great part played by this country in the advancement of knowledge), he arrives at the more restricted subject of Metallurgy itself.

Here Sir Robert concerns himself with ferrous metals alone, beginning with a consideration of iron and the older carbon steels, and thus leading up to what may be described as the essential part of the address: namely, the alloy steels, and especially those two, manganese steel and tungsten steel, which he himself first obtained and introduced to the engineering world.

In this part of the address Sir Robert paints some fascinating pictures, enlivened with many human touches relating both to himself and to his fellow workers and assistants. We learn of the actual preparation and perfecting of the new alloys, the exploration of their properties and their gradual adoption for industrial purposes.

Though prevented by lack of time from any full treatment, Sir Robert nevertheless contrives to deal briefly with rustless steels and with the heat treatment of steels in general before closing with a short appreciation of the future of science in connexion with its relation to our national life.

It is difficult in the course of a short review to give an adequate idea of the immense amount of ground covered by the address, which is the more impressive when one learns that " the work had to be done without relaxing or holding up the pressure of ordinary everyday affairs." Mention must lastly be made of the twenty-seven interesting plates, many of which are portraits, with which the reprint is illustrated.

REPORTS ON THE PROGRESS OF APPLIED CHEMISTRY. VOL. IX, 1924. Edited by T. F. Burton. London: The Society of Chemical Industry. 12s. 6d. to Non-Members of the Society, 7s. 6d. to Members.

It would be difficult to overestimate the debt of gratitude owed by chemists to the indefatigable compilers of this annual volume, as also to those who contribute to the similar, though smaller, production of the Chemical Society. To sift out, select and condense into a coherent account the abstracts of the whole year's output of work in industrial chemistry is really a stupendous task, even when shared, as in the present instance, among twenty-seven contributors, especially since it must be remembered that these are necessarily busy men, each probably fully occupied with other work.

Industrial conditions are of course reflected in this annual to a much greater extent than in publications dealing with pure science, and it is gratifying to see that on the whole the note struck in most of the sections is one of optimism, sometimes rather tempered, and not shared at all by the acid and alkali industry, while rubber is none too happy financially, and leather is handicapped by high prices for raw materials.

A frequent observation is the real advance which is being made in the application of the scientfic spirit in place of rule of thumb; and it is no matter for surprise that the effects of the British Empire Exhibition are beginning to receive attention and assessment.

As regards scientific progress, the volume is of course essentially a work of reference, and it is not easy to select the most striking results achieved. It may be remarked, however, that much interest has attached to nitrogen fixation, beet sugar manufacture, smoke abatement, the motor fuel problem, the production and dyeing of artificial silk, the World Power Conference at Wembley (the Transactions of which have been published at the rather staggering price of £12), the preparation of insulin, and the lessons of the Oppau explosion.

Altogether the editor is to be congratulated on a valuable achievement.

COAL RESEARCH ASSOCIATION.

The coal owners of the country have formed the British Colliery Owners' Research Association for the purpose of fostering and financing research through existing agencies, such as the laboratories of the universities, rather than by undertaking it itself. Its activities will also be co-ordinated with those of organisations already established for the promotion of the health and safety of those who work in coal-mines, and the better utilisation of coal fuel.

One of the first problems to be tackled by the new association will be the more economical production of coal. Funds will be provided in the form of grants from the Mining Association of Great Britain, and the constitution of the organisation is being modelled on the lines of that of the parent body.

In addition to fostering practical research, the Association will publish periodicals and books dealing with coal, and the mining of it. It is hoped also to establish a certain number of museums, to investigate the qualities of new inventions having a bearing upon coal-mining and to encourage the training of skilled professional workers.

MEETING OF THE SOCIETY.

◆

Dominions and Colonies Section.

Thursday afternoon, at 4.30 o'clock:—

June 18.—Hon. W. G. A. Ormsby-Gore, M.P., Under Secretary of State for the Colonies, "Some African Problems." The Rt. Hon. J. H. Thomas, M.P., will preside.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

◆

Monday, June 15..Victoria Institute, Central Hall, Westminster, S.W. 4.30 p.m. Dr. A. T. Schofield, "The Capture of the Unconscious."

Botanic Society, Inner Circle, Regent's Park, N.W. 3 p.m. Lecture on "Temporary, Variable and Double Stars."

University of London, University College, Gower Street, W.C. 5.30 p.m. Profs. A. V. Hill and J. C. Drummond, "Biochemistry." (Lecture VII.)
At King's College, Strand, W.C. 5.30 p.m. Dr. R. Dyboski, "The New Poland." (Lecture VIII.)

Tuesday, June 16..Statistical Society, at the Royal Society of Arts, John Street, Adelphi, W.C. 5.15 p.m.

Mineralogical Society, at the Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

Asiatic Society, at the Royal United Service Institution, Whitehall, S.W., 4.30 p.m. Mr. H. St. J. B. Philby, "The Recent History of the Hijaz." (Sir Richard Burton Memorial Lecture.)

Wednesday, June 17..Meteorological Society, 49, Cromwell Road, S.W. 5 p.m. 1. Messrs. J. E. Clark, I. D. Margary and R. Marshall, "Report on the Phenological Observations in the British Isles from December, 1923, to November, 1924." 2. Messrs D. N. Harrison and G. M. B. Dobson, "Measurements of the amount of Ozone in the Upper Atmosphere.' 3. Mr. Joseph Baxendell, "Meteorological Periodicities of the order of a few years, and their local investigation; with special reference to the term of 5.1 years in Britain."

British Academy, at the Royal Society, Burlington House, Piccadilly, W. 5 p.m. Mr. E. Maclagan, "The Appreciation of Sculpture."

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. J. S. Phillimore, "Manuscript Tradition and Critical Probability in the Text of Propertius." (Lecture I.) Lectures II and III on June 18th and 19th.

Thursday, June 18..Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Chemical Society, Burlington House, Piccadilly, W. 8 p.m. 1. Mr. H. Phillips, "Investigations on the dependence of rotatory power on chemical constitution. Part XXVII. Some esters of p-toluene sulphonic and sulphinic acids." 2. Messrs. F. R. Goss and C. K. Ingold, "The enhanced reactivity of newly-formed molecules. Part I. The conversion of cyclols into ketones." 3. Mr. F. H. McDowall, "Constituents of *Myoporum lactum* Forst ('The Ngaio.')". 4, Messrs. J. Kalff and R. Robinson. A synthesis of datiscetin.

5. Messrs. J. Allan, A. E. Oxford, R. Robinson and J. C. Smith, The relative directive powers of groups of the form RO- and RR'N- in aromatic substitutions.' Part IV. A discussion of the observations recorded in Parts I, II, and III.

Tropical Medicine and Hygiene, Royal Society of; 11, Chandos Street, W. at 8.15 p.m. 1. Dr. G. C. Low, "On the Use of a drug named 'Smalarina' in the treatment of Malaria." 2. Prof. Yorke, "Further Observations of Malaria made during Treatment of General Paralysis."

Anthropological Society, 52, Upper Bedford Place, W.C. 4.30 p.m. (Indian Section.) Mrs. S. Stevenson, "The Dheds."

Antiquaries Society, Burlington House, Piccadilly, W. 8.30 p.m.

Institut Francais du Royaume Uni, 3, Cromwell Gardens, S.W. 9 p.m. M. M. Thiéry, "Les Journalistes et la Révolution de 1830."

University of London, University College Hospital Medical School, Gower Street, W.C. 5 p.m. Dr. J. Hay, "Cardiology." (Lecture III.) Lecture IV on June 19th.
At King's College, Strand, W.C. 6.30 p.m. Dr. O. Vocadlo, "The Czechoslovak Republic To-day." (Lecture IX.)

JOURNAL OF THE ROYAL SOCIETY OF ARTS.

No. 3,787. VOL. LXXIII.

FRIDAY, JUNE 19, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. 2.

FINANCIAL STATEMENT FOR 1924.

The following statement is published in this week's *Journal* in accordance with Sec. 40 of the Society's By-laws:—

INCOME AND EXPENDITURE ACCOUNT.

January 1st to December 31st, 1924.

Dr.

	£	s.	d.	£	s.	d.
To *Journal*, including Printing, Publishing and Advertisements	3,201	6	6			
" Library and Bookbinding ..	82	1	4			
" Medals :—						
Albert 21 16 6						
Society's 32 3 6	54	0	0			
" Sections :—						
Dominions and Colonies 82 6 3						
Indian 125 10 3	207	16	6			
" Cantor Lectures	177	5	0	3,722	9	4
" Expenses of Examinations..				9,643	8	8
" House :—						
Rent, Rates, and Taxes ..	434	13	5			
Insurance, Gas, Coal, Expenses and Charges incidental to Meetings............	567	4	9			
Repairs	245	4	6	1,247		8
" Office Expenses :—						
Salaries, Wages, and Pensions	3,807	16	9			
Stationery and Office Printing	385	5	9			
Advertising	15	0	0			
Postages, Parcels, and Messengers' Fares	224	11	9	4,432	14	3
" Committees :—						
General Expenses				47	17	8
" Industrial Art Committees .				148	14	9
" Interest on Bank Overdraft				289	16	5
" Balance, being Excess of Income over Expenditure transferred to Capital Account (see Balance Sheet)........				974	4	7
				£20,506	8	4

Cr.

	£	s.	d.	£	s.	d.
By Subscriptions	6,306	0	6			
" Life Compositions	549	18	0	6,856	7	6
" Interest and Dividends on Society's Investments ..	352	17	11			
" Ground Rents	383	18	11			
" Interest, Dividends, and Ground Rents from Trust Funds for General Purposes	499	7	10			
Do. from Building and Endowment Funds	22	7	5	1,258	12	1
" Sales, etc. :—						
Journal	229	18	10			
Do. Advertisements	326	2	9			
Cantor Lectures	22	17	1	578	18	8
" Examination Fees and Advertisements in and Sale of Examination Papers				11,490	9	0
" Charges for Expenses for the use of Meeting Room				255	3	0
" Rent of Cellars				66	18	
				£20.506	8	

TRUST INCOME AND EXPENDITURE ACCOUNTS.

Dr.

	£	s.	d
Balance forward	584	2	2
	£584	2	2

Cr.

					£	s.	d.	Trust Accumulations, Dec. 31st, 1924. £	s.	d.
	John Stock Trust—									
By	Balance, January 1st, 1924				35	16	7			
,,	Interest on Investments				3	10	2			
								39	6	9
	North London Exhibition Trust.—									
,,	Balance, January 1st, 1924....				45	9	10			
,,	Interest on Investments				6	14	10			
					52	4	8			
	Less Prizes awarded				1	14	2			
								50	10	6
	Dr. Aldred's Trust—									
,,	Balance, January 1st, 1924				52	4	0			
,,	Interest on Investments				7	14	5			
								59	18	5
	Thomas Howard's Trust—									
,,	Balance, January 1st, 1924				57	19	0			
,,	Interest on Investments				19	19	8			
								77	18	8
	Mulready Trust—									
,,	Balance, January 1st, 1924				33	12	9			
,,	Interest on Investments				5	5	4			
								38	18	1
	Dr. Swiney's Trust—									
,,	Balance, January 1st, 1924				200	0	0			
,,	Ground Rents (Income from)..				180	0	0			
					380	0	0			
	Less Cup and Prize awarded to Sir Paul Vinogradoff	200	0	0						
	Less Transfer to Society's Income & Expenditure a/c ..	140	0	0						
					340	0	0			
								40	0	0
	Francis Cobb Trust—									
,,	Balance, January 1st, 1924				56	12	3			
,,	Interest on Investments				8	18	10			
					65	11	1			
	Less Cost of T. S. Price's Lectures				38	7	6			
								27	3	7
	Le Neve Foster Prize Trust—									
,,	Balance, January 1st, 1924				25	15	4			
,,	Interest on Investments				5	16	0			
								31	11	4
	Fothergill Trust—									
,,	Balance, January 1st, 1924				76	4	3			
,,	Interest on Investments				13	12	5			
								89	16	8
	Trueman Wood Lecture Trust—									
,,	Interest on Investments				32	14	8			
	Less cost of Sir W. Pope's Lecture (including printing)				32	14	8			
								–	–	–
	Benjamin Shaw Trust—									
,,	Balance, January 1st, 1924				8	16	8			
,,	Interest on Investments				4	13	6			
								13	10	2
	Cantor Trust—									
,,	Interest on Investments				140	5	2			
,,	Ground Rents (Income from)..				141	0	0			
					281	5	2			
	Less Transfer to Society's Income and Expenditure Account				281	5	2			
								–	–	–
	Davis Trust—									
,,	Interest on Investments				78	2	8			
	Less Transfer to Society's Income & Expenditure Account				78	2	8			
								–	–	–
,,	Sir George Birdwood Memorial Trust—									
	Interest on Investments				36	15	0			
	Less cost of W. Foster's Lecture (including Printing)........				36	15	0			
								–	–	–
	Russian Embassy Prize Trust—									
,,	Balance, January 1st, 1924				10	0	0			
,,	Interest on Investments				5	0	0			
								15	0	0
	Dr. Mann Trust—									
,,	Balance, January 1st, 1924				89	5	6			
,,	Interest on Investments				51	8	6			
					140	14	0			
	Less Cost of Juvenile Lectures				40	6	0			
								100	8	0
	Owen Jones Memorial Trust—									
To	Interest on Investments				15	13	4			
	Less Prizes awarded				15	13	4			
								–	–	–
								£584	2	2

1925—Jan. 1. By Balance brought forward £584 2 2

BALANCE SHEET, December 31st, 1924.

Dr.

	£	s.	d.	£	s.	d.
To Capital Account—						
As on January 1st, 1924 ..	73,522	12	7			
Donations *re* Building Fund	188	12	0			
Income and Expenditure Account Balance	974	4	7			
				74,685	0	2
„ Sundry Creditors				1,415	15	2
„ Bank Overdraft				5,715	3	8
„ Industrial Art Fund (Donations received and not yet expended)				903	18	0
				82,720	6	0
„ Trust Funds—						
Capital Account	16,899	7	5			
Accumulations under Trust Income and Expenditure Account	584	2	2			
				17,483	9	7
„ Sundry Creditors				8	7	6
				£100,212	3	1

Cr.

	£	s.	d.	£	s.	d.
By Freehold Premises						
18 and 19, John Street as on December, 31st, 1923				50,392	16	7
„ Books, Pictures, etc.......				10,000	0	0
„ Investments (see schedule)				17,481	8	5
„ Subscriptions outstanding				2,540	0	0
„ Sundry Debtors and Ground Rents outstanding				888	10	8
„ Paid on Account of 1925 Examinations				1,920	0	0
				83,222	15	8
„ Trust Funds—						
Investments	16,899	7	5			
Ground Rents, etc.	90	0	0			
				16,989	7	5
				£100,212	3	1

We have audited the above Accounts and Balance Sheet for 1924 *with the books, accounts and vouchers relating thereto, and certify them as being in accordance therewith. We have verified the Bank Balances and investments.*

KNOX, CROPPER & Co.,
Chartered Accountants.

Spencer House, South Place, E.C. 2.
6th June. 1925.

SCHEDULE OF THE SOCIETY'S INVESTMENTS.

(as valued December, 1922*).*

£	s.	d.		£	s.	d.
			Ground-rents (amount invested)	£10,496	2	9
£217	0	0	Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock	157	0	0
£500	0	0	New South Wales 4 per Cent. Stock	445	0	0
£500	0	0	Canada 3½ per Cent. Stock	430	0	0
£100	0	0	Queensland 4 per Cent. Stock	97	0	0
£530	10	1	New South Wales 5 per Cent. Stock	514	11	0
£500	0	0	Natal 4 per Cent. Stock	445	0	0
£321	15	9	Metropolitan Water Board "B" Stock	200	3	0
£6	0	0	New River Company Shares	6	0	0
£3,408	14	6	India 3½ per Cent. Stock	2,181	11	8
£500	0	0	South Australia 4 per Cent. Stock	500	0	0
£2 000	0	0	War Loan 5 per Cent..	2,000	0	0
				£17,481	8	5

TRUST FUNDS INVESTMENTS SCHEDULE.

	£	s.	d.
Alfred Davies Bequest	£1,053	0	0
Mr. Swiney's Bequest	4,477	10	0
Mr. Cantor's Bequest	2,695	11	3
Mulready Trust	105	9	9
Howard Trust	571	0	0
Owen Jones Trust	522	3	2
Mr. Cantor's Bequest	3,273 648	16 10	6 7
J. Murray and others, Building Fund	20 38	16 11	4 0
Francis Cobb Trust	255	14	1
Le Neve Foster Trust	105 42	11 2	7 1
John Stock Trust	70	4	0
Shaw Trust	93	12	0
North London Exhibition Trust	134	17	0
Fothergill Trust	272	7	6
Aldred Trust	154	8	0
Endowment Fund	394	7	0
"Trueman Wood" Lecture Endowment Fund	654	15	7
Sir George Birdwood Memorial Fund	734	10	9
Russian Embassy Prize	100	0	0
ann Trust	1,028	9	2

	£	s.	d.
Great Indian Peninsula Railway 4 per cent. Guaranteed Debenture Stock	£1,800	0	0
Ground-rents (amount expended)	4,477	10	0
Do. do. do.	2,695	11	3
National 5 per cent. War Bond, 1927	109	10	1
Metropolitan Railway 3½ per Cent. Stock	510	9	5
India 3 per cent. Stock	423	0	0
Do. do. Bombay and Baroda Railway Guaranteed 3 per Cent. Stock	2 573	10	0
India 3½ per Cent. Stock	20	10	0
5 per Cent. War Loan	54	18	0
New South Wales 3½ per Cent. Stock 1930-50	250	0	0
3½ per Cent. War Loan	100	0	0
5 do. do.	40	0	0
5 do. do.	100	0	0
5 do. do.	129	0	0
5 do. do.	184	15	8
5 do. do.	374	0	0
5 do. do.	210	17	6
5 do. do.	525	2	3
National 5 per Cent. War Bonds 1928	654	18	1
5 per Cent. War Loan	674	0	0
5 do. do.	91	9	3
5 do. do.	900	0	0
	£16 899	7	5

NOTICES.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One-hundred-and-seventy-first Annual General Meeting, for the purpose of receiving the Council's Report and the Financial Statement for 1924, and also for the election of Officers and new Fellows, will be held, in accordance with the By-laws, on Wednesday, June 24th, at 4 p.m.

(By Order of the Council)

George Kenneth Menzies,
Secretary.

SOCIETY'S ALBERT MEDAL.

The Albert Medal of the Society for the current year has been awarded by the Council, with the approval of His Royal Highness the President, to Lieut.-Colonel Sir David Prain, C.M.G., C.I.E., M.B., LL.D., F.R.S., "for the application of Botany to the development of the raw materials of the Empire."

FUND FOR PURCHASING THE SOCIETY'S HOUSE.

The following contributions to the Fund for Purchasing the Society's House have been received since the last announcement was published in the *Journal*:—

	£	s.	d.
Amount previously acknowledged	42,931	15	5
P. Elahi Buksh, Esq.	5	0	0
Cyrus B. Haldeman, Esq.	5	0	0
James Robinson, Esq., Assoc.M.Inst.C.E.	2	2	0
John Nimmo Wardrop, Esq.	2	2	0
Professor John Uri Lloyd, Ph.D., LL.D. (in addition to previous donations amounting to £14 19s.)	1	17	0
Percy Hamilton McKay, Esq. (second donation)	1	1	0
	£42,948	17	5

Fellows of the Society are reminded that the amount aimed at by the Council is £50,000, which will cover the cost of renovating and decorating the House.

INDIAN SECTION.

FRIDAY, 12TH JUNE, 1925. SIR LOUIS W. DANE, G.C.I.E., C.S.I., in the Chair.

A paper on "The Heart of Asia and the Roof of the World" was read by BRIG.-GEN. SIR PERCY SYKES, K.C.I.E., C.B., C.M.G.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

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TWENTY-SECOND ORDINARY MEETING.

WEDNESDAY, MAY 20TH, 1925.

MR. A. A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council, in the Chair.

THE CHAIRMAN, in introducing Professor Fleming, said that the Society had met that evening to celebrate the centenary of the electro-magnet, and it was very fortunate in having Professor Fleming, one of the best lecturers on electrical subjects in the world, to address it on this occasion. Professor Fleming had been at a great deal of pains to set up apparatus for demonstration, and he was sure that the evening would prove a most interesting one.

The paper read was :—

WILLIAM STURGEON AND THE CENTENARY OF THE ELECTROMAGNET.

By Professor J. A. Fleming, D.Sc., F.R.S.

One hundred years ago, almost to a day or two, in May, 1825, a Paper was presented to this Society, and published in its Transactions for that year,(1) in which was described for the first time an instrument in a rudimentary form which proved to be one of the great inventions of electrical science. That invention was the electromagnet with soft iron core, and the inventor of it was William Sturgeon, whose name and work we desire to commemorate to-day.

Five years before that date, Hans Christian Oersted, of Copenhagen, had announced in a Latin thesis published on July 21st, 1820, his discovery, made early in April, 1820, that the wire joining the terminals of a voltaic pile possessed the power of causing a freely suspended magnetic needle to place itself at right angles to the wire, and thus laid the foundation stone of a new branch of science, viz., electromagnetism.

In the same year Arago, in France, had drawn the logical conclusion and verified experimentally that a steel needle laid at right angles to the wire conveying a voltaic current should become permanently magnetised.(2) On seeing this experiment, Ampère had at once made the suggestion that the effect would be improved by winding the wire spirally round the needle, and this was found to be the case.

The next few years furnished more contributions to our knowledge of the magnetic properties of a wire conveying an electric current made by the genius of Ampère, Arago, De la Rive, Schweigger, Faraday and Barlow, but to none of these brilliant investigators came the idea that temporary and instantly reversible powerful magnetisation could be bestowed upon a bar of soft iron by embracing it by a helix of wire through which an electric current from a voltaic battery was sent.

That conception first sprang up in the mind of a self-taught electrical amateur, William Sturgeon, a shoemaker by trade and at one time a private soldier in the 2nd Battalion of the Royal Artillery, who, though weighted with grave disadvantages from lowly birth and imperfect education, was yet remarkable for his great abilities and enthusiasm as an electrical investigator. He gave to science an imperishable donation in the electromagnet which proved to be the basis on which has been erected nearly all the subsequent developments of electrotechnics.

The electromagnet in some form or another is the fundamental element in the dynamo, the electric motor, the transformer, of nearly every telegraphic instrument, of the telephone, the loading coil, the electric bell, and is the most effective means of exerting mechanical force at a distance, or actuating and controlling mechanism of any kind.

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(1) See *Transactions of the Society of Arts.* Vol. 43, p. 38, 1825.

(2) Arago. *Annals de Chemie et de Physique.* Vol. 15, 1820. The same fact was discovered independently by Davy. *Annals of Philosophy,* 1821.

In 1825, William Sturgeon presented to the Society of Arts a collection of apparatus made with his own hands, for illustrating the principal facts of the new science of electromagnetism in which he was a pioneer, and the Society gave him in recognition its silver medal and a premium of thirty guineas.

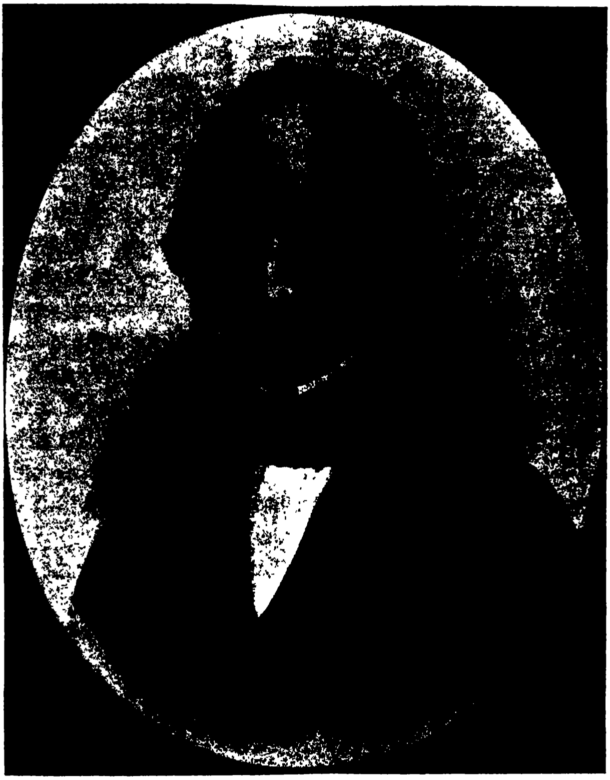

Fig. 1—William Sturgeon, Inventor of the Electromagnet, 1783-1850.

The following paragraph is a verbatim extract from the Minutes of the Society of Arts for May 18th, 1825, kindly furnished by Mr. G. K. Menzies :—

> " A Report from the same Committee (Committee of Mechanics) on Mr. Sturgeon's apparatus for exhibiting the principles of electro-magnetism and on giving him the silver Vulcan medal and Fifteen Guineas as a bounty for the same, being read :—
>
> An Amendment was proposed by Mr. Gill and seconded by Mr. D. Campbell that the words *Silver Medal and Thirty Guineas* be substituted for those of *Silver Vulcan Medal and Fifteen Guineas*, as a Bounty, on

condition of his leaving a complete apparatus and description thereof with the Society for the use of the Public and relinquishing all pretensions to a Patent, and that the words concluding the Resolution, viz., *on condition of his leaving his apparatus with the Society for the purpose of making drawings*, be omitted, which was agreed to.

The Report so amended was put and agreed to."

Also the following paragraph is an extract from the Minutes of the Society of Arts, for May 21st, 1825, concerning the same Award :—

" On reading those parts of the Minutes which related to.......... Mr. Sturgeon's apparatus for exhibiting the principles of electro magnetism and on giving him the Silver Medal and Thirty Guineas as a Bounty for the same..............Ballots were taken and the Bounties confirmed."

Amongst this apparatus was a horseshoe of soft iron formed of a round bar about 12 inches long and about ½ an inch in diameter. This was varnished with some insulating material and had wound upon it 18 turns of bare copper wire, the ends of which dipped into two mercury cups. These cups were also the terminals of a single voltaic cell, comprising two plates of copper and zinc spirally interwired without touching, exposing about one square foot of opposed surface. The plates were immersed in a pot of dilute acid. The resistance of the whole circuit being low, the current was fairly large, and when the connection was made the iron became powerfully magnetised, and when a cross bar of iron was put across the ends of the horseshoe, it sustained a weight of 9 lbs. Sturgeon showed that when the connections of the magnet wire and battery were reversed, the polarity of the magnet changed, and that the magnetism disappeared when that circuit was interrupted.

The following extract is taken from Sturgeon's Paper in the Transactions of the Society of Arts (loc. cit.)

Extract from the account of Sturgeon's Electro-Magnet Apparatus, Transactions of the Society, Vol. XLIII, page 48, 1825.

" Figs. 13 and 14. A front and side view of a stand with two connecting cups Z and C made of wood, in which the bent iron wire wound round with copper wire is supported by the two copper wire ends. On making the galvanic connection through the copper wire, the iron wire becomes a strong horseshoe magnet, and will support a heavy bar of iron as *y* fig. 14; but on lifting the connection wire *d* fig. 13, out of the cup Z, the weight immediately drops, and on restoring the connection, the power is restored, then if you change Z for C, it will change N for S, or if you only wrap the copper wire about the iron wire, as a right threaded screw instead of a left one, as in the drawing, it will change N for S. This is explained by what takes place in figs. 7, 8, and 9."

Sturgeon also included in his gift a straight bar electromagnet wound over with a single layer of bare copper wire and adapted to be placed in the same mercury cups as the horseshoe.

Sturgeon's horseshoe magnet had an iron core weighing 7 ounces, and it could therefore sustain about 20 times its own weight when magnetised. Unfortunately, in the lapse of time and the changes which have taken place, this invaluable relic, the first electromagnet, has disappeared, and I am therefore only able to present to you a replica constructed by me to imitate it, from the diagram and data given by Sturgeon himself in his paper. Sturgeon's important invention instantly commanded attention and numerous electricians endeavoured to improve it by increasing the sustaining power of the magnet.

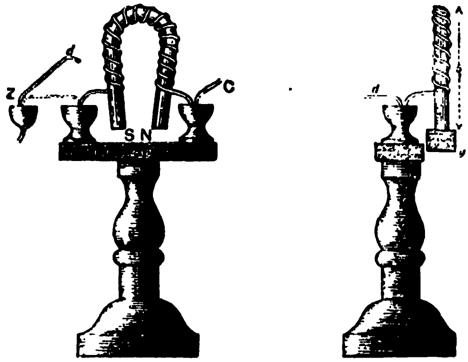

Fig. 2—The first Electromagnet made by William Sturgeon, and presented to the Royal Society of Arts.

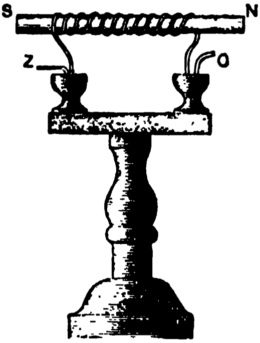

Fig. 3—Sturgeon's Straight Bar Electromagnet.

Things, however, which are now familiar even to babes in electromagnetism were then hidden from the wise and prudent, and years of experimental groping in the dark had to take place before the now well understood properties of the electric and magnetic circuits and the relation of their fundamental measurable qualities were clearly ascertained. It was not until two years after Sturgeon gave us the electromagnet, that Dr. G. S. Ohm, in Germany, in 1827, published his epoch-making essay or thesis on the "Galvanic circuit mathematically investigated," in which he enunciated the celebrated Ohm's Law(3).

Even when important new physical phenomena have been observed, some considerable time generally elapses before a clear recognition is reached as to the special qualities or quantities which must be named and measured and their interconnections sought. It was, therefore, only by degrees seen that in the electromagnet we have two intertwined paths or circuits called the electric and magnetic circuits in which exist two states or fluxes called respectively the electric current and the magnetic flux, which states are produced by two agencies, viz., the electromotive and the magnetomotive forces. These fluxes are, so to speak, limited in amount for given forces by two qualities of the circuits called their electric resistance and magnetic reluctance, or we may say are permitted by reciprocal qualities, viz., the electric conductance and magnetic permeability of these circuits.

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(3) *Die Galvanische Kette Mathematisch bearbeitet.* For the English Translation see *Taylor's Scientific Memoirs, Vol. II, p.* 401. 1841.

Ohm's work was announced in a book published by him in Berlin in 1827, but was not made known in England until 1841, by the Translation in *Taylor's Scientific Memoirs.*

The three factors are connected by similar relations. In the electric circuit the current is proportional to the electromotive force and inversely as the resistance of the circuit. In the magnetic circuit the magnetic flux is proportional to the magnetomotive force and inversely as the reluctance. But there is this great difference, that whereas the electric resistance at the same temperature is independent of the current flowing in the magnetic circuit, the magnetic reluctance or its reciprocal the permeance is a function of, and depends on, the magnetic flux. Moreover, there is a cross connection between the two circuital laws which is expressed by saying that the magnetomotive force in the magnetic circuit is proportional to the product of the current in the electric circuit, and to the number of turns this current makes round the magnetic circuit. In other words, the magnetising power of the current depends on the product of the current and the turns or on the ampère-turns.

There are also many important differences between the two circuits which depend on the fact that whereas we can insulate completely an electric current, that is, keep it in a required path, we cannot insulate magnetic flux or constrain it to exist only in an assigned circuit. Moreover, the electric current in an electric circuit dies away very quickly when the electromotive force is removed, but the magnetic flux may continue to exist for an indefinite time in a magnetic circuit after the magnetomotive force has been withdrawn.

The matter which chiefly excited scientific interest in connection with Sturgeon's invention was the lifting power of the electromagnet or force required to detach a piece of soft iron called an armature from the poles. An immense number of observations were accumulated, and empirical rules formulated, but the Law of Traction, as it is called, was stated in its greatest simplicity by Maxwell in his Treatise on Electricity and Magnetism in the following form:—

If we consider a magnetic circuit say of iron to be traversed by a magnetic flux the density of which reckoned in " lines per square centimetre " is B, and if A is the area of cross section of the circuit, then if we imagine the circuit cut across the pull in grammes weight required to separate the parts is $(B^2A)/(981 \times 8\pi)$. It is, in fact, proportional to the square of the magnetic flux density.

Amongst those who endeavoured to produce electromagnets of great lifting power were J. P. Joule, afterwards celebrated for his thermodynamical researches, and Joseph Henry, then a teacher in the Albany Institute, New York. Henry succeeded in 1828 in improving Sturgeon's electromagnet by winding it with many turns of fine copper wire insulated with silk in place of the single bare winding employed by Sturgeon. He thus produced what he called " intensity magnets," which required only a small electric current, but one generated by a large number of voltaic cells in series, to operate them.

Under these conditions, Henry was able to actuate his electromagnet at a distance through a copper wire of no great thickness, whereas Sturgeon's single winding magnet could only exhibit lifting power when worked close to its battery of one large cell. The reasons for these facts, so obvious to us now in the light of Ohm's Law, were then extremely puzzling to the pioneers in electromagnetism. Henry's employment of insulated or covered wire for the windings of his electromagnet was a great step in advance. He, in fact, discovered that the magnetising power of the current depended on the product ot the current and the turns of wire, and that it was possible to produce powerful magnetisation by a small current provided the number of turns of wire through which it circulated round the iron was large. This enabled him to actuate electromagnets at a distance by means of a small electric current transmitted through a thin copper wire and thus made possible telegraphic instruments such as those of Morse and Hughes.

J. P. Joule gave his attention chiefly to improving the lifting power of the electromagnet.

Sturgeon had left the Army and removed his residence from Woolwich in London to Manchester in 1838, where he had been called to act as Superintendent of the Royal Victoria Gallery of Science, an institution intended, like the Adelaide Gallery in London and the old Polytechnic in Regent Street, to foster a popular interest in science. All of these institutions, however, after a few years of unremitting labour on the part of their founders and superintendents, failed to obtain sufficient support from a public more intent on amusement than on the acquirement of scientific knowledge.

Sturgeon had in 1836 started a monthly periodical called the *Annals of Electricity*, by the circulation of which, and by itinerant lecturing, he endeavoured to support himself and his family. He was thus brought in contact with Mr. James Prescot Joule, a Manchester brewer. Joule contributed to Sturgeon's journal an account of his own electromagnetic researches.

Without giving any clear expression of magnetic theory, Joule obviously aimed at increasing the magnetic flux in the magnetic circuit by decreasing its reluctance. With this object, he greatly increased the cross section of the iron core of his electromagnet and shortened its magnetic length, and also reduced the reluctance of the circuit by improving the contact surfaces of the magnet and armature.

One of Joule's electromagnets was in the form of an iron tube with one sector cut off so as to be able to wind the major part with insulated wire. The smaller iron part constituted the armature. There was thus a good contact surface of large area and a magnetic circuit of small reluctance. A certain Joule tubular electromagnet, weighing only 15 lbs., required a pull of nearly 2.100 lbs., or 1 ton, to detach its armature.

Joule also devised a form of electromagnet of two parts, each comprising a disk of iron with iron teeth set perpendicularly to the disk like a crown wheel.

The wire winding was put on the teeth zigzag fashion. The two parts of the magnet were placed tooth to tooth and the polarity of the teeth was alternately North and South round the circumference. Joule thus produced electromagnets of great lifting power for the current employed, and his success was due to the increase in the magnetic flux density for a given magnetomotive force in ampère-turns, brought about by enlargement of the cross section and reduction in the length of the magnetic circuit.

In recent years such lifting magnets have become of industrial importance in lifting scrap iron and steel borings, and turnings and iron castings too hot to touch, all of which are difficult to handle by manual power. Also, large electromagnets are used to raise heavy iron balls, called skull crackers, which are then allowed to fall from a height and thus break up old iron castings or disused machinery for melting down again.

Electromagnetic clutches and breaks for tramcars are other applications of electromagnets of great tractive power.

The work of Sturgeon, Henry and Joule enabled large electromagnets giving powerful interpolar fields to be constructed and furnished scientific investigators with a new and powerful tool.

Thus Faraday had constructed for the Royal Institution several electromagnets. With one of these he made his famous discovery of the rotation of the plane of polarised light by a magnetic field. With another constructed in 1845 and still preserved at the Royal Institution, he conducted his great researches on magnetism and diamagnetism.

Similar large electromagnets were made by other physicists, such as Plücker in 1847, and with even more powerful electromagnets physical effects such as Zeeman's discovery in 1896 of the multiplication of the lines in the spectrum by a strong magnetic field, which was looked for in vain by Faraday, have been discovered.

The complete scientific study of the electromagnet may be said to have begun only with its application in the construction of the dynamo. Just as the attempt to lay long submarine cables compelled attention to the electric qualities of copper and to the measurement of electric quantities, so the use of iron in dynamos necessitated a closer scrutiny of the magnetic qualities of iron and of the measurement of magnetic quantities. The work of Lord Kelvin and the researches of Sir Alfred Ewing on this subject are classical and fundamental. Neither can we forget nor forbear to mention the labours of Rowland, Bosanquet, Heaviside and the Brothers Hopkinson, which greatly illuminated the subject.

The introduction of the ring method of experiment, first suggested by Kirchhoff, and employed by Rowland, Bosanquet and Hopkinson, made use of a poleless electromagnet with homogeneous circuit, thus eliminating the complications involved in a magnetic circuit partly of iron and partly of air. Winding over such a ring with a known number of turns of insulated wire and sending a measured electric current through the wire, we apply to the iron a known magnetomotive force, and create in it a magnetic flux reckoned in so many lines or kilolines per square centimetre of cross section. If we embrace the ring with a secondary coil of known resistance and known number of turns and suddenly reverse the direction of the magnetising current, the magnetic flux is reversed in direction and as a consequence of Faraday's Law, an induced electromotive force is created in the secondary circuit and a quantity of electricity urged through it which is proportional to the flux. In this manner we can measure two quantities, viz., the magnetising force H or magnetomotive force per unit of length of the magnetic circuit and the magnetic flux density B or lines of flux per square centimetre of cross section of the magnetic circuit, and can plot a curve called a B-H, curve for that iron. The ratio of B to H at each point of the curve is called the permeability (μ), and the permeability curve for iron begins with a value of about 100-400 for small magnetising force and rises up to about 5,000-6,000 units for ordinary soft iron and then falls off again towards a low value of 100 or less as the iron reaches its state of saturation when B ceases to increase with H.

The consideration of these facts long ago suggested that the process of magnetising iron does not consist in the creation of a new physical state but in the bestowing identity of orientation upon a number of elementary magnetic particles or units which in the non-magnetic condition are arranged in a disorderly manner. This theory of magnetisation, commonly attributed to Weber, explains in a general way a number of facts and the reason for the form of the magnetisation curve. Also it supplies a plausible explanation for the facts of magnetic retentivity or that some magnetisation remains after the magnetising force is withdrawn. The Weber theory also supplies in a certain approximate manner an explanation of the phenomena of cyclical magnetisation.

If we apply a gradually increasing magnetic force in one direction to a bar of iron and then reverse it, and carry it to an equal value in the opposite direction and finally bring it back again to zero, we operate on the iron with a cycle of magnetic force. If the corresponding values of the magnetic flux are measured at each stage and the cyclical B-H curve plotted out, we have a closed curve called by Sir Alfred Ewing a *hysteresis curve* because the flux lags behind the force at each step. The area of this curve is proportional to the work done on the material per unit of volume in carrying it through this magnetic cycle. This hysteresis loss is, therefore, of enormous importance in connection with alternating current electromagnets as it implies an energy-dissipation in the material. It was soon found that small variations in the chemical constitution and physical state of the material had an immense influence on this hysteresis loss as also upon the permeability of the material.

Accordingly, as soon as electrical engineering work began on a large scale, builders of dynamos and of transformers made demands on iron and steel manufacturers for special materials. One kind of iron or steel was required which had the highest magnetic permeability under flux densities near to saturation. This has been produced in the form of a steel which is nearly pure iron. It was required for the field magnets of dynamos. A different kind of material was required for transformer cores and alternating current work, viz., one in which the hysteresis loss was as small as possible and the electric conductivity also small, so as to hinder what is called eddy current losses. A special type of low carbon silicon steel was discovered by Sir Robert Hadfield in 1882, which gives us an immensely valuable material for this purpose.

Quite recently a third demand has been put forward for a magnetic material which must have extremely large magnetic permeability for very low magnetising forces and at the same time very large electric resistivity. Such material is required for the uniform loading or over winding of telephone and telegraph cables to which fuller reference is to be presently made. In spite of the wide range of magnetic properties involved, iron and steel manufacturers have been able to meet these requirements in a most remarkable manner.

A brief reference to the physical constitution of the ferromagnetic metals and their alloys will be of help in understanding something of the way in which this has been done.

In the 8th column of the Mendelejeff's Periodic Series of the Elements there are three groups each of three metals of approximately the same atomic weights and consecutive atomic numbers. For present purposes the most important of these is the Iron, Cobalt, Nickel group called the Ferromagnetic Metals. Faraday showed that all the remaining elements can be divided into two classes, viz., paramagnetic and diamagnetic, and these may be defined by saying that the paramagnetic class have slightly greater permeability or conducting power for lines of magnetic flux than vacuum, and the diamagnetic class slightly less permeability.

The ferromagnetic metals, have, however, enormously greater permeability than vacuum, and also when magnetic flux has been created through them it may persist after the magnetising force is withdrawn, thus making them exhibit permanent magnetisation. This unique ferromagnetic property, however, disappears if these metals are heated beyond a certain temperature, and it disappears also if those ferromagnetic metals are alloyed with certain other metals or elements even when the ferromagnetic metal is present in largest proportion.

Very roughly speaking, the temperature at which the special ferromagnetic property disappears and is reduced merely to paramagnetic power is for iron about 780° C., for cobalt 1090° C., and for nickel 360° C. These temperatures are not sharply marked. There is for each metal a range of rising temperature over which the permeability first rapidly increases, and then quickly falls down again to nearly unity.

Another most notable fact is that alloys in certain proportions of the ferromagnetic metals or ferromagnetic and certain paramagnetic metals are often destitute of ferromagnetic properties. A striking instance is the Manganese steel discovered by Sir Robert Hadfield in 1882. This consists of 88 per cent. of iron, 12 per cent. of manganese and small amounts of carbon, silicon, etc. The permeability of this alloy in its normal condition is only 1.3, or about the same as that of liquid oxygen. It is a paramagnetic substance. I am indebted to Sir Robert Hadfield for a specimen of this alloy I now exhibit. The remarkable fact is that if this alloy is heated for at least 60 hours to 400°C. or 500°C. and then rolled slowly it passes into a magnetic condition in which it possesses a considerable magnetic permeability and a bar of this manganese-steel so treated can be lifted up by a permanent steel magnet, whereas in its normal condition this manganese-steel is not attracted by a magnet.

Another instance is the non-magnetic cast-iron of Messrs. S. E. Dawson and Ferranti. Its composition is 81 per cent. iron, 6 per cent. manganese, 9 per cent. nickel, and although possessing all the mechanical properties of good soft cast-iron, the magnetic permeability of this material is only about 1.3. Filings or turnings of the material are somewhat more magnetic than the mass. A description of the preparation and properties of this non-magnetic cast-iron given by Mr. S. E. Dawson will be found in *The Foundry Trade Journal* for May 20th, 1924, and also in the British Patent Specification No. 204,598 of November 25, 1920. This material in its ordinary condition has a magnetic permeability of 1.02 and after heating to 900° C. and annealing this increases to 1.12. If previous to this heat treatment it is plunged in liquid air and cooled to—190° C. its permeability is increased to 2.03. If cooled in liquid air after the heat treatments its permeability is increased to 7.62 and it is easily attracted and lifted by a magnet. These figures were obtained by experiments made at University College, London, in the Electrical Engineering Department by Mr. S. R. Witt. The late Dr. John Hopkinson pointed out 40 years ago (in 1885), the remarkable power of the element manganese when present in any large proportion in iron to reduce the permeability of the material to values not much above unity.

The element manganese appears not only to have the power of destroying ferromagnetic qualities in iron but also of creating them in non-ferrous alloys. An instance of this is the Heusler alloy of manganese, copper and aluminium. The two latter are normally diamagnetic elements, but an alloy in the proportions of manganese 22.42 per cent., copper 60.49 per cent. and aluminium 11.65 per cent., has marked ferromagnetic properties. It exhibits normal magnetisation and hysteresis curves, and has a maximum permeability of about 28-30 as shown in an examination of it by Sir Robert Hadfield and me in 1905.(4) This alloy nearly corresponds in composition to a molecular formula, $Mn\ Al\ Cu_2$, the percentage composition of which would be Mn 26 per cent., Cu. 60.2 per cent., Al 12.8 per cent. nearly.

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(4) See J. A. Fleming and R. A. Hadfield, *Proc. Roy. Soc., Lond.*, Vol. A. 76, p. 271. 1905. On the magnetic qualities of some alloys not containing iron.

The curious thing is that the manganese-copper alloy having 30 per cent. manganese and 70 per cent. copper is nearly non-magnetic, but the addition of the third element, which may be either aluminium arsenic, antimony, zinc, or tin, was found by Heusler to bestow at once ferromagnetic properties on the alloy. This seems to point strongly to the facts as stated in the above mentioned paper by Sir Robert Hadfield and me, that ferromagnetism cannot altogether be an atomic property merely but must depend in some way on a special molecular grouping.

A vast number of facts have been collected in the last half century concerning the vagaries of the nickel-iron alloys in varying proportions and the extraordinary effects of temperature upon them.

Dr. J. Hopkinson showed in 1890 that an alloy of 75 per cent. iron, and 25 per cent. nickel, both strongly ferromagnetic metals, had a permeability of only 1.4 for any value of the magnetising force. It was practically non-magnetic. If, however, this alloy was cooled to 0° C., or below the freezing point of water, it became as magnetic as cast iron ($\mu=62$ for $H=40$), and retained this augmented permeability. If then it is heated to 580° C. it passes back into the non-magnetic condition, and retains it until once more cooled below zero centigrade. Hence at atmospheric temperatures this alloy can exist in two different states, one highly magnetic and the other practically non-magnetic. Sir Robert Hadfield has been so kind as to send me a bar of this nickel steel having the composition Ni. 26%, Mn. 1.15%, Si. 0.78%, C. 0.52%, Fe. 71.55%. In its normal condition it is non-magnetic. If heated to 900°C. and then immersed for half its length in liquid air the half so immersed becomes magnetic, and as you will see, presents the curious phenomenon of a bar which is in one half magnetic and in the other non-magnetic.

But a more important nickel-iron alloy has been investigated and prepared of late in the Research Laboratories of the American Telephone and Telegraph Company and of the Western Electric Company in U.S.A. which has been called Permalloy. It consists of 78½ per cent. of nickel, and 21½ per cent. of iron, and is remarkable for its immensely enhanced permeability under low magnetic forces. The special utility of this alloy is in the uniform or continuous loading of telephonic and telegraphic cables.

Time will not permit any full statement of the theory of the telephone cable. Suffice it to say, that when a wave or train of electric current waves is sent along a cable, the wave form of that current corresponding to the acoustic wave form of some articulate sound, the small ripples or irregularities or so-called higher harmonics in that wave form die out more quickly than the fundamental wave. Hence a long telephone cable distorts the speech waves, and beyond a certain distance they become unintelligible when translated back to sound.

The late Mr. Oliver Heaviside was the first to show that this distortion could be reduced by "loading" the cable or giving it more inductance or electric inertia. His ideas were put in practical form by Professor I. Pupin, of New

York, when he inserted " loading coils," which are, in fact, poleless electromagnets at proper intervals in the line.

Another and more feasible method for submarine cables is the Krarup or uniform loading in which the copper conductor is wound closely over with one or more layers of iron. The magnetic forces brought into existence by the feeble telephonic currents are, however, very small, not more than 0.2 of a C.G.S. unit, and hence to obtain much useful result we require a magnetic material which has a very large permeability for very small magnetic forces.

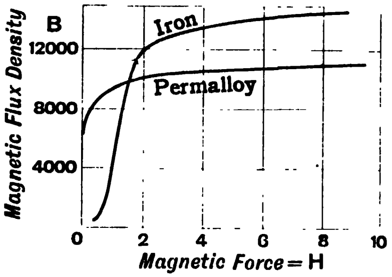


Fig. 4—Magnetisation Curves for Iron and Permalloy.

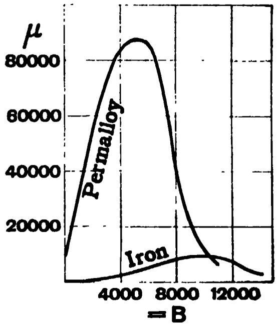


Fig. 5—Curves of Permeability of Iron and Permalloy.

This is exactly what the permalloy gives us. At or near zero magnetic force the permeability of the best soft iron may be about 100 or from 200 to 400 at most. For permalloy, a permeability of 13,000 has been found for zero magnetic force. For magnetic forces not exceeding .05 C.G.S. unit or a quarter of the earth's horizontal magnetic force in England the permeability of permalloy may reach 87,000 to 100,000 or more. The curious thing is, that for large magnetic forces the permeability may be less than that of soft iron. On the other hand, the permalloy possesses far less hysteresis loss and much greater electric resistance than the purest soft iron.

We are thus presented with a material having very surprising and unique magnetic and electric qualities, and the interesting question which presents itself is how to account for these on any accepted or possible theory of ferromagnetism.

Some three years ago, Sir Alfred Ewing published an important paper on Models of Ferromagnetic Induction, in which he showed that a ferro-magnetic body cannot be represented simply by rows of pivoted small magnets which are colineated in direction by an external magnetising force and constrained by their interaction on one another. (See *Proceedings* of the Royal Society of Edinburgh, Vol. 42. p. 97, 1922.) He gave reasons for believing that the magnetic element or Weber element which turns under the action of the magnetising force on iron is not the atom as a whole but some displaceable part in the atom. By ingenious models he represented the atom, say of iron, as consisting of something equivalent to 8 fixed magnets at the corners of a cube, and the rotable part as a set of 4 pivoted and interconnected magnets in the centre. The control which resists the colineation of these movable parts comes from the outer shell of each atom itself and not from the mutual action of neighbouring atoms. Although the theory has much to recommend it when we are considering only pure simple ferromagnetics such as iron, it is difficult to find in it an explanation of the peculiar effect of manganese in destroying ferromagnetic power even when present only to the extent of 10 or 12 per cent. Nor does it seem to explain the ferromagnetism of the Heusler alloys, nor the magnetic anomalies of the nickel-iron alloys. It demands a special supplementary assumption to account for the disappearance of ferromagnetism at and beyond a certain temperature. The X-ray spectroscopic analysis and microstructure examination has shown us that there are definite crystal structures in iron and steel which have relation to the mechanical and magnetic qualities of iron in its various allotropic forms. The X-ray analysis reveals that the atoms are arranged in certain regular groupings o lattices. The atoms can vibrate about certain mean positions, and no doubt also rotate round certain axes.

We know little or nothing about the nature of the force which holds together the atoms in solid bodies, commonly called the cohesive force. All our knowledge about the atom seems, however, to indicate that it is an electrical structure built up of protons and electrons, and hence the parts of an atom are held together by electric forces.

It is not, therefore, unreasonable to assume that the cohesive force is also electric and that the atom has polarities or regions on its surface, as far as it can be said to have a surface, at which these are manifested. Accordingly atoms will tend to arrange themselves in certain regular groupings to satisfy these polar attractions and repulsions just as a collection of pivoted magnets in proximity would do.

The atom according to the Rutherford-Bohr theory comprises a nucleus around which revolve in various orbits a family of electrons in number equal to the *atomic number* of the atom. These orbits are not always circular but may be ellipses of great eccentricity, neither are the orbits always co-planar.

These electrons cannot rotate round the nucleus at any and every possible distance but only in certain orbits called quantum paths, in which the angular momentum for a circular orbit is an exact integer multiple of a certain small unit, called the Planck Constant, and for elliptic orbits is determined by three quantum numbers. Also, according to Bohr's theory, when an electron is circulating in a quantum path it does not radiate energy nor does it produce any magnetic field.

Radiation and, therefore, the production of a magnetic field only takes place when an electron jumps or is propelled from one quantum path to another or is disturbed from its quantum orbit. It has often been assumed that the molecular or atomic electric currents, which, in accordance with Ampère's theory, are the cause of paramagnetism and ferromagnetism in certain types of atoms, are due to the orbital revolution of the planetary electrons round the nucleus. But this theory proves too much, for if it were true then nearly all atoms should be paramagnetic and ferromagnetic, whereas in fact the ferromagnetic property is confined to a very small group of atoms with atomic numbers 25, 26, 27, and 28.

One fact confirmatory of Bohr's theory that an electron revolving round a nucleus in a quantum path does not create a magnetic field, is that the atom of hydrogen which appears to consist of a single electron revolving round a nucleus, and which, therefore, on the ordinary theory should be paramagnetic is, on the contrary, both in gaseous or liquid phase, diamagnetic. It would seem then that the only electron orbit which can be operative in producing atomic magnetism is the outermost orbit from which electrons are continually being disengaged or taken up again, and, therefore, moving into and out of quantum paths, whilst preserving an angular momentum with respect to the nucleus for a limited time. These detachable electrons are generally called the valency electrons.

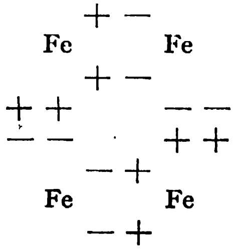
There seems to be a tendency or desire on the part of the atom to make up the number of electrons in the outermost layer or quantum path to eight.

If the total negative charge represented by all the planetary electrons is equal to the resultant positive charge on the nucleus the atom is in a neutral condition. If it loses electrons from any layer it becomes a positive ion, and if it takes up electrons in its outer layer it becomes a negative ion, and positive and negative ions can combine to form a neutral molecule.

In the neutral iron atom there are 26 planetary electrons and it may have 2, 3, or 6 electrons in the outer orbit. The iron atom is generally quadrivalent and can take up 4 or lose 4 or 6 electrons from its outermost quantum orbit.

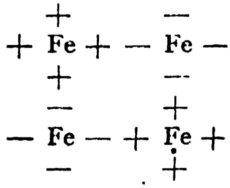
Then those charged iron atoms can combine into an iron molecule. Iron atoms which have lost electrons and, therefore, become positive ions can combine with iron atoms which have taken up electrons and, therefore, become negative ions.

Thus it is possible to have an iron molecule composed of 4 atoms of iron united by electrical attractions. Two of these atoms have lost 4 electrons and are, therefore, positively electrified and two have gained 4 electrons and are, therefore, negative. The graphic representation would then be either as in (*a*) or (*b*) as below.



(*a*)

or



(*b*)

The molecule (*a*) the affinities are all self-satisfied and the molecule is, therefore, electrically neutral. In (*b*) there are 8 free affinities and hence this 4-atom iron molecule can combine with other similar molecules to build up cubes and fibres of iron molecules. The X-ray analysis and microscopic examination shows that this is the structure of ferrite or pure iron. The existence of this 4-atom molecule of iron is furthermore indicated by the known fact that a carbon-iron molecule Fe_3C called *cementite* is present in certain steels. It is an extremely hard substance and is obviously a 4-atom molecule of ferrite with one atom of iron replaced by one of carbon.

The cubic crystal lattices and fibres of iron so built up are not separate but inter-connected in such fashion that each cubic crystal of 8 iron atoms has another iron atom at its centre. Also each atom at the corner of a cube is common to 8 cubes. This complete crystal is called a body-centred cubic lattice. It is the crystalline form of pure iron or ferrite in its so-called Alpha or magnetic condition. In it the iron atom is probably quadrivalent.

If the iron is heated to 800° C. or above, it changes its crystalline form and becomes converted into a face-centred cubic lattice in which there is an iron atom at each corner of the cube and one in the centre of each face. It is probable that in this case the iron atom is hexavalent. At that temperature the iron is non-magnetic and is in the form called Gamma-iron by metallurgists. We have not yet, however, solved the problem of the true physical difference between the atom of Alpha-iron and that of Gamma-iron. Out of all the 88 kinds of known atoms only 3, viz., iron, cobalt, and nickel, exhibit marked ferromagnetic properties, and Alpha-Iron is predominant amongst these three. The main difficulty is to decide whether ferromagnetism is an atomic property or is dependent on certain molecular groupings (5). Sir William Bragg has expressed the opinion to the Author that there does not seem to be any evidence the ferromagnetic property is conectned with any particular lattice structure.

Some iron compounds such as the ferrocyanides and iron-carbonyl are even diamagnetic. The addition of 10 or 12 per cent. of manganese to iron which means the intermingling of the atom of manganese with 8 of iron destroys altogether the ferromagnetic property of the 88 per cent. of iron in the mass. In the 25 per cent. nickel-iron alloy the compound formed of 1 atom of nickel to 3 of iron may be magnetic or non-magnetic at the same temperature according to previous treatment. It appears, however, that the iron in these alloys as determined by the lattice structure is in the state of Gamma-iron even at the ordinary temperature.

It is possible, therefore, that the manganese acts as a so-called catalyst and promotes the change from Alpha to Gamma-iron just as a small quantity of iodine promotes the change of ordinary phosphorus into the allotropic red phosphorus. Moreover, manganese seems to retard or prevent the return of the iron from the Gamma- to the Alpha-form, even when reduced to normal or lower temperatures. The two allotropic forms of iron, Alpha and Gamma, are quite as different in properties as the two forms of phosphorus, and that change is no doubt accompanied by a change in the number and grouping of the external shells of electrons.

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(5) The following are important papers on the Crystalline Structure of Iron and Alloys.

A. Westgreen. *Engineering*, Vol III, p. 727, 1921.
A. H. Hull. *Physical Review*, Vol. 13, p. 692, 1917, and Vol. 17, p. 571, 1921.
L. W. McKeehan. *Journal of Franklin Institute*, Vol. 197, p. 583, 1924.

Some assistance in probing this matter is derived from a study of the remarkable alloy Permalloy. The composition of the nickel-iron alloy which has the highest magnetic permeability for small magnetic force is 78.5 per cent. of nickel and 21.5 per cent. of iron, and this corresponds very nearly to an atomic proportion of 4 atoms of nickel to 1 atom of iron. Sir William Bragg has kindly examined for me samples of Permalloy by X-ray analysis and has found that the lattice is a face-centred cube with length of side equal to 3.55 Angstrom units (A.U.).

The X-ray analysis shows that in nickel the crystal lattice is also a face centred cubic lattice in which 8 atoms of nickel stand at the cube corners and 6 in the centre of each face. In consequence of the fact that each corner atom is common to 8 cubes and each face atom to 2 cubes the whole crystal group is equivalent to 4 atoms of nickel.

The iron atom in Permalloy is very little controlled by other iron atoms and is free to exhibit its full magnetic alignment under very feeble magnetic forces.

High permeability implies that the magnetic element in the iron whether the atom itself or some part inside the atom, in accordance with Sir Alfred Ewing's theory, is very free to align itself under feeble magnetic force, and but little constrained by the action of neighbouring atoms. Hence with the crystal structure suggested the material would probably have this property.

The arrangement of atoms in two samples of magnetic Heusler alloy composed of Manganese, Copper and Aluminium has been examined by J. F. T. Young of Toronto, and he found in them by X-ray analysis a body centred cubic lattice structure and no trace of the lattices of the component metals which, taken by themselves, exhibit faced centred cubic lattices.

This last seems to be the crystalline form of Gamma-Iron.

The lattice form must, however, depend upon some atomic structure which tends to make the atoms arrange themselves in one form rather than the other. The change of lattice in passing from Alpha to Gamma-Iron and vice-versa is also accompanied by a change in the closeness of packing of the atoms and by the loss or regaining of ferromagnetic power.

Sir William Bragg has told us that in the Alpha-Iron each iron atom has 8 nearest neighbours, but in Gamma-Iron it has 12 nearest neighbours.

There is, therefore, a pulling together of the iron atoms as we pass from the Alpha to the Gamma form.

This is well shown by the familiar experiment in which an iron wire is heated to about 900° C. by an electric current and then allowed to cool. The steady contraction as cooling is interrupted—at about 800° C.—by a sudden small expansion and the iron at that moment regains its ferromagnetic property. I have arranged here a simple experiment in which an iron wire can be heated by an electric current sent through it and at the same time magnetised by an electric current circulating round it. The apparatus has a lever attachment which shows the expansion of the wire and there is also a suspended magnetic needle which shows by its deflection whether the iron wire is magnetic or not. If the wire is heated to a bright-red heat and then allowed to cool at a certain temperature the lever shows by its motion that there is a momentary expansion of the wire. At the same instant the indicating magnetic needle shows that the γ- iron has passed back into the magnetic condition or into the α iron.

Perhaps the following suggestions may not be found altogether at variance with the facts.

When the iron is heated the increase in the vibrations of the atoms as a whole and of their constituent electrons causes a loss of electrons (perhaps of two), from the outer shell or electronic orbits.

In this outer layer the electrons are continually being disturbed from their steady revolution in quantum paths. Therefore they create by their motion a magnetic field, and we can, perhaps, say that the magnetic moment of the iron atoms is due to the disturbed electronic revolutions in the outer layer.

If, therefore, an external magnetic field acts on the iron it tends to set the plane of these magnetic orbits perpendicular to the direction of the field. This is resisted by the field of the atom and action of the neighbouring atoms. Accordingly, the "Weber element" of the atom is, as Ewing proves, not the atom as a whole, but a portion of it, viz., the outer electron orbits.

Any further loss of electrons from this layer or any combination of iron atoms into a molecule by depriving it of those electrons to which the magnetic moment is due or fixing the plane of their orbits so as to prevent co-lineation would, therefore, destroy or greatly reduce the atomic magnetic moment and remove the " Weber element," to which the applied external magnetising field gives co-lineation.

Accordingly, at a certain temperature, when this electronic loss takes place, the iron atom passes into the Gamma condition. It then ceases to be ferromagnetic and changes its crystal lattice form and the atoms are pulled closer together. We can, perhaps, explain the action of manganese in depriving Alpha-Iron of its ferromagnetic quality in the same way. Manganese occurs in the Periodic Table of the Elements in the same column as the Haloids F., Cl., Br., and I. These elements are strongly electronegative, and desire to take up electrons in their outer atomic shells. Therefore, manganese mixed in a sufficient proportion with iron may deprive the Alpha-Iron atoms of electrons and reduce it to the condition of Gamma-Iron, which is retained even when the metal is brought back to the atmospheric temperature. The explanation of the action of nickel is not so easy. The nickel steels appear to possess very considerable thermo-magnetic hysteresis, that is, the magnetic changes of the material with temperature lag behind the thermal changes and hence, at normal temperature, we can have the material in one of two states in which it is magnetic or non-magnetic according to its previous treatment.

The feeble ferromagnetism of the Heusler alloys may, perhaps, also be explained by the fact that the manganese takes up electrons from the copper and the aluminium atoms and to a small extent then simulates in itself the structure of the iron atom.

The unsolved problems of ferromagnetism are, however, many and complex, and we cannot yet say that we understand even imperfectly the phenomena connected with Sturgeon's electromagnet.

Let one word more be said in conclusion about Sturgeon himself. Unfortunately, after the failure of the Victoria Institute in Manchester, Sturgeon's later years were spent in great penury. Scientific research was not then a paying proposition, to use an American phrase. The late Professor Silvanus Thompson tells us in his admirable sketch of Sturgeon's life that Dr. Lee, Bishop of Manchester, and Dr. Binney, President of the Literary and Philosophical Society of Manchester, succeeded in obtaining for Sturgeon from Lord John Russell a grant from the Civil List of £200 to meet his greatest necessities and a pension of £50 per annum soon after. Sturgeon did not, however, benefit by it for long, as he died in 1850 at Prestwich, near Manchester, and was buried in Prestwich Churchyard, where a stone records his name and date of death.

Mr. James Prescot Joule, who entertained a high opinion of Sturgeon's work, stated in a letter to Dr. Angus Smith that he had sifted to the utmost Sturgeon's claims to be the inventor of the electromagnet, and had found them valid.

Sturgeon was also the first to improve the voltaic cell by amalgamating the zinc plates, and so preventing that loss of zinc by local action which was previously the great drawback to the use of Volta's pile.

He was also the first, according to Dr. Joule, to construct an electromagnetic motor in 1832, by means of which any considerable rotary power was obtained from an electric current, and he may thus be said to have been one, at least, of the pioneers who gave us the electric motor.

Sturgeon's personal character, his high principles, blameless life, devotion to scientific truth and discovery, his genuine scientific achievements, as also his brave struggle against adverse fortune, brought him the respect and friendship of all good men. We can, therefore, include him confidently amongst those British scientific worthies who helped to lay firm and strong the foundations on which have been built up the great edifice of modern electrical engineering.

Beyond any question, his name must be inscribed in the records of those whose labours have enabled us yet more to utilise the great energies of Nature for the use and benefit of mankind.

DISCUSSION.

Mr. W. M. Mordey said that on this occasion, as always, he had learned a great deal from Professor Fleming. He was very glad indeed that Professor Fleming had given prominence to the work of Sturgeon, who had never had proper recognition of his work—he did not know why. Faraday, for some reason or other, did not recognise Sturgeon's work. Most of those present would have read that charming little *Life* of Faraday by Silvanus Thompson ; in that little book, which gave such a beautiful picture of that good, almost saintly man, Thompson spoke of one flaw—his unwillingness to recognise Sturgeon's work in electro-magnetism, which was quite incomprehensible. Faraday always attributed the invention of the electro-magnet to Moll, and to Henry, although both of those men, in their later work on the electro-magnet, frankly stated that their work was founded on the discovery made by Sturgeon. Yet, in spite of that, and in spite of what was said by Joule, Faraday, our greatest discoverer, failed to appreciate Sturgeon's work, and very few people knew of it.

He was pleased to see the model which the lecturer had exhibited. It was exactly copied from the account given in Sturgeon's papers. As the Royal Society of Arts had not got a copy of Sturgeon's *Researches*, he had brought his own copy for exhibition that evening. It was an enormous work entitled *The Researches, Experimental and Theoretical, on Electricity, Magnetism*, etc., and was published by subscription in 1850, about a year after Sturgeon's death. It was illustrated with a number of beautiful copperplate engravings, one of which was of the electro-magnet shown by the lecturer. There were also many illustrations of discoveries that he made in what were called Arago rotations at that time, but all those, he thought, were more or less improvements in detail on the work of other people on this subject. With regard to what the lecturer had said about Henry's original telegraph between his house and his garden, there was an entry in the *Researches* which showed very distinctly the element of telegraphy. The polarised needle was described, and an arrangement intended to show how the needle could be deflected and so on by reversing the current. It showed quite clearly that Sturgeon had sound ideas on the subject of this application. That was demonstrated in the electro-magnet, where he used a very thick wire with very few turns, and placed his battery close underneath so that he got the greatest possible effect. He realised the best conditions just as well as if he had known a great deal about Ohm's law.

The speaker was also very glad to hear the remarks of Professor Fleming on the subject of permalloy. This was one of the most extraordinary inventions ever made in electro-magnetism. He did not think that if the problem had been put to any scientific people in the world it could have been foretold that an alloy could be made with the properties possessed by this wonderful material. They would have scoffed at the idea. This alloy had been discovered as the result of a research for something that was very badly wanted. Its value to the world was probably to be reckoned in millions of pounds.

DR. J. F. CROWLEY said that the address made one wish that centenaries of great events and great men were celebrated more frequently. The decade to which this centenary carried them back was of peculiar interest both to physicists and electrical engineers. To physicists it recalled the establishment of a close connexion between the two sciences. Prior to 1820 an association between magnetism and electricity was suspected, but it had not to any extent been demonstrated, but, during the years from 1820 to the epoch-making discovery of Faraday in 1831, that association had been made definitely clear, and the period was one of extraordinary interest to the physicist. Since that time the association between chemistry and electricity had also been demonstrated. The period in question was of peculiar interest to the electrical engineer also, because, if electrical engineering could be traced to any clear origin, it could certainly be traced to the electro-magnet of Sturgeon, and to the production of electricity by the movement of coils of wire in the neighbourhood of a magnet by Faraday in 1831. He thought he might say in passing that the fact that the one hundred years which had elapsed had shown such extraordinary progress in electrical engineering, not only in the magnitude of the works carried out, but also in the reduction of waste of energy in the machinery employed, was largely due to the scientific character of the work on electricity and magnetism from the very beginning, and the necessity for a scientific training for the undertaking of that work. It was certainly a notable achievement that to-day we should have great electrical machines with an efficiency of 96 or 98 per cent., and possibly even more remarkable was the production of electrical motors of under 1 h.p. with an efficiency of 88 per cent.

There had been what might prove to be a very valuable contribution to the production of suitable irons and suitable steels for magnetic purposes, principally during and since the war, namely, the production on a large commercial scale of electrolytic iron—iron which was 99.8 per cent. pure—sometimes even higher. The electrolytic deposition of iron in a very thin form had been known for very many years, but the production of a suitable iron for commercial purposes was a very recent development. That iron, suitably treated, was widely used in mechanical industry, and it might prove of very considerable assistance in the production of suitable alloys for electrical machinery and other purposes. He felt deeply indebted to the lecturer, and it was also good to feel that the work of Sturgeon had been recognised, at any rate, by that Society.

COLONEL R. E. B. CROMPTON, C.B., said that, like previous speakers, he came to learn, and he had succeeded in knowing what a great deal he had still to learn. He was one of those people who were more indebted to Professor Fleming than most. At a very early stage, when they were all in the dark on this question, the lecturer came forward and gave them aid which the speaker never could forget. That evening the speaker had come for the sheer pleasure of hearing Professor Fleming, and he had not been disappointed. As an old man he felt an ever growing sense of wonder at the marvellous world he lived in, and the many interesting problems ahead. After forty or fifty years of work on electricity he felt that they had only reached the threshold of a realm of which those who followed could now travel. Within the last few years he had had a good deal to do with the extraordinary development of the cobalt alloys which had enabled the commercial magneto machine to be made of such small dimensions and weight and with such satisfactory results. The Institution of Mechanical Engineers two or three years ago called upon him to make experiments on cobalt alloys with the object of showing that this extraordinary metal behaved at high temperature in a way different from any alloy that had been investigated. He then found that certain iron alloys with cobalt gave permanent magnets of extremely small weight, and he stumbled on this sample by reason of the enormous difficulty which it produced in his laboratory in dealing with everything that came near the lathe by means of which the experiments were carried on; everything became magnetised. This, he believed, was well known to the lecturer, but there was no doubt that as a commercial idea the cobalt iron alloy was the permanent magnet that was likely to be used in the next few years. He had to thank Professor Fleming for a most interesting evening.

COMMANDER ROLLO APPLEYARD desired to add his tribute to that which had been given by Colonel Crompton. Dr. Fleming not only taught, he inspired. He showed engineers what their difficulties were and how he disposed of them, and by experiment he led them on as he had done that evening. In some ways it was encouraging for the younger men to realise how many of these problems were unsolved. There was just one other point: Sturgeon's work was entirely experimental, and his experiments were carried out with the simplest apparatus. To-day we had elaborate testing apparatus and more precise knowledge. The difficulties were greater, but the equipment was better suited to the task The name of Sturgeon would be associated with a great victory with s[illegible]apons. He thanked the Society for the opportunity it had afforded thos[illegible]ested in Sturgeon's work to do honour to his memory, and he thanked his old friend and teacher Dr. Fleming for his delightful discourse.

THE CHAIRMAN (MR. CAMPBELL SWINTON) said that there was no doubt that Dr. Fleming was the most finished experimental lecturer living, probably in the world, certainly by a long way in this country. The curious thing was that his experiments always succeeded. He (the Chairman), had attended a great many lectures of Dr. Fleming, some of them with an enormous number of experiments—hundreds of experiments—and not one of the experiments failed. He did not know how it was done, but it was a most remarkable fact. Dr. Fleming also was never at a loss for a word. Everybody had sincerely enjoyed what he had shown that evening. Beginning with such a simple matter as Sturgeon's original magnet, he had told them a great deal about recent important researches—very important ones from the financial point of view—for cables and things of that kind. It has been a delightful historical lecture, finishing up with a great deal of information about the very latest investigations on this subject. He asked those present to accord Dr. Fleming a very hearty vote of thanks.

The metion was carried unanimously.

DR. FLEMING expressed his great appreciation of the compliment. It was abundantly clear from the remarks of the Chairman and others who had spoken that Sturgeon well deserved recognition and remembrance, even after one hundred years. He thought it would be useful if a Sturgeon lecture were delivered once a year in the Society's hall at about that date, in which some authority on electromagnetism would describe the latest results. He was sure there would be abundant material in the book Mr. Mordey had exhibited for the historical background of such a course of lectures.

THE CHAIRMAN said that he would see that this valuable suggestion was brought to the notice of the Council.

OBITUARY.

LIEUT.-GEN. H.H. THE MAHARAJA OF GWALIOR.—Lieut.-Gen. H.H. Maharaja Sir Maho Rao Scindia, G.C.S.I., G.C.V.O., G.B.E., A.D.C., the much-respected ruler of the Indian State of Gwalior, died in Paris on June 12. He was born in 1876, succeeding to the *gadi* in 1886 on the death of his father, Maharaja Jaiaji Rao Scindia, a staunch friend of the British raj in the Mutiny. In his devotion to the Paramount Power Sir Maho Rao followed the example of his predecessor, and it has been said that no contemporary feudatory chief had a warmer place in the personal regard and affection of the King, Emperor of India. On the birth of a son and heir to tne Maharaja, His Majesty, in assenting to the request that the boy might be named after him, cabled: "I rejoice that a successor to your ever loyal line is thus secured, and I trust that the son will follow in the footsteps of his father." His Highness's only other child, a girl, bears the name of Queen Mary. Amongst the earlier benefits the Maharaja bestowed upon his people were a State Trust and Bank, a Council of State, a Legislative Assembly and an Advisory National Assembly. On the military side he was equally energetic and sagacious, modernising the Gwalior forces and developing the Imperial Service troops, with the result that first in the relief of Chitral and next in connexion with the Tirah expedition he was in a position to aid with his well-known Transport Corps. At his own urgent wish he was employed in the Allied operations in China, being a member of the staff of the Commander of the British Contingent, Sir Alfred Gaselee. For the use of the sick and wounded in that campaign he provided a hospital ship with staff and full equipment. Although the state of his health prevented him from personally serving on the Western Front in the Great War, a portion of his Imperial Service Infantry distinguished itself in East Africa, Palestine and Mesopotamia, while several squadrons of Gwalior Lancers assisted in India and on the North-West Frontier, his Highness's Transport Corps also doing efficient duty in East Africa, Egypt and Mesopotamia as well as on the Western Front. He also helped the common cause by granting to the Imperial Government a large loan without interest, formed at Nairobi a convalescent home for our officers serving in East Africa, and purchased one of the Canadian Pacific liners for conversion into a hospital ship. The honours bestowed upon him after the war included the valued increase of his salute to the maximum of 21 guns.

The Maharaja was a Fellow of the Royal Society of Arts, having been elected in 1915.

GENERAL NOTE.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.—In the Supplemental Charter recently granted to the R.I.B.A., provision is made for the formation of a non-corporate class of subscribers. The Council have the power to elect to this new class any persons who, not being professional architects, are interested in the activities of the Royal Institute and in architectural matters generally. "Subscribers" will be entitled to use the Loan and Reference Library, to attend all General Meetings (except private business meetings) and to receive a copy of the Annual Report. The annual contribution payable by a "Subscriber" will be £1 1s.

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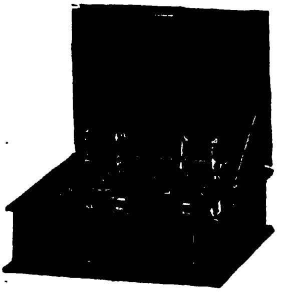

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JOURNAL OF THE ROYAL SOCIETY OF ARTS

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FRIDAY, JUNE 26, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

ANNUAL GENERAL MEETING.

WEDNESDAY, JUNE 24TH, 1925, SIR CHARLES STUART BAYLEY, G.C.I.E., K.C.S.I., in the Chair. The One-hundred-and-Seventy-First Annual General Meeting of the Society was held for the purpose of receiving the Council's Report, and the Financial Statement for 1924, and also for the Election of Officers and new Fellows.

A full report of the Meeting will be published in the next issue of the *Journal.*

COUNCIL.

A meeting of the Council was held on Monday, June 15th. Present:—Mr. Alan A. Campbell Swinton, F.R.S., in the Chair; Sir Charles H. Armstrong; Sir Frank Baines, C.V.O., C.B.E.; Viscount Bearsted, LL.D.; Captain Sir Acton Blake, K.C.M.G., K.C.V.O.; Sir William Henry Davison, K.B.E., D.L., M.P.; Sir Archibald Denny, Bt., LL.D.; Sir Robert Hadfield, Bt., D.Sc., D.Met., F.R.S.; Rear-Admiral James de Courcy Hamilton, M.V.O.; Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.; Major Sir Humphrey Leggett, D.S.O., R.E.; Sir Philip Magnus, Bt.; Sir Charles C. McLeod, Bt.; Mr. Carmichael Thomas; and Sir Frank Warner, K.B.E., with Mr. G. K. Menzies, M.A. (Secretary of the Society) and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

A letter from the President was read, signifying His Royal Highness's approval of the award of the Society's Albert Medal for the current year to Lieut.-Colonel Sir David Prain, C.M.G., C.I.E., M.B., LL.D., F.R.S., and the terms of the award were settled.

The balloting list for the new Council was completed.

The draft report of the Council for the year 1924-25 was considered, amended and approved for submission at the Annual General Meeting.

A report from the Thomas Gray Memorial Trust Committee was considered.

A proposal to institute an annual William Sturgeon Lecture was considered.

Other formal business was transacted.

DOMINIONS AND COLONIES SECTION.

THURSDAY, JUNE 18TH, 1925. RT. HON. J. H. THOMAS, M.P., late Secretary of State for the Colonies, in the Chair.

A paper on "Some African Problems" was read by the HON. W. ORMSBY-GORE, M.P., Under Secretary of State for the Colonies.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, MAY 22ND, 1925.

SIR THOMAS HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S., in the Chair.

THE CHAIRMAN, in introducing Sir Alfred Chatterton, said that the Society was to be congratulated on the opportunity of tapping the accumulated mental resources of the one man—the only man—who was able to furnish a picture in true perspective of the industrial progress of the Mysore State. Sir Alfred went out to India 37 years ago, after a very distinguished record at the City and Guilds Engineering College. He commenced his activities in Madras, and after some years in the service as a professor of engineering he recognised the necessity of taking up the wider industrial problems that obviously offered an opportunity for profitable solution in the southern part of India. In various ways his energy found an outlet in picking up and developing one industry after another, not exactly in the face of opposition, which might have been a stimulant, but in the face of inertia on the part of those whose lives he attempted by his activities to benefit, and also in the face of an equal amount of indifference on the part of the orthodox officials who should have supported his efforts. By 1908 the meaning of this work began to impress the Local Government. The Madras Government by that time had established a Department of Industries and placed Sir Alfred Chatterton in control. The Department was designed to give effect to a desire for the development of obviously primitive industries. It was a good beginning, but it came late. After another four years Sir Alfred Chatterton reached a stage in his official career when it was possible for him to retire and transfer his energies to the Mysore State. His problem there was narrower geographically, but his opportunities were greater in other respects, as he was given a free hand to develop and organise a State policy. In another four years the Government of India appointed an Industrial Commission, of which Sir Alfred Chatterton, to the great advantage of all concerned, became a member. With an experience such as his, based on sound technical training and inspired by missionary enthusiasm, his presence on the Commission made up for the shortcomings of a good many witnesses. Whatever merits were now recognisable in the official report of the Industrial Commission were largely due to the advantages which it derived from

Sir Alfred's ripe experience in the difficult problem of evolving order out of the enormous mass of facts and suggestions which were brought to its notice. He had continued his direct touch with the Mysore State since 1912, and he came, therefore, to the Society with a mind still well acquainted with the conditions there, and he was able to give a thumb-nail sketch of the industrial state of Mysore in a way that would not be possible for any other official with whom the speaker was acquainted. Sir Alfred Chatterton was now able also to bring to bear on the Mysore problems observations made in every other Province in India.

The paper read was :—

THE INDUSTRIAL PROGRESS OF THE MYSORE STATE.

By Sir Alfred Chatterton, C.I.E., B.Sc., M.I.M.E., Assoc.M.Inst.C.E.

The unrest in India, as elsewhere, is partly, and perhaps largely, due to the inability of certain classes of the people to adapt themselves to changes which have taken place in their economic environment. Incomes have not increased proportionately to the depreciation in the value of the currency and many, through no fault of their own, are suffering from inadequate means to maintain the standard of living they formerly enjoyed. This causes discontent and, unable to appreciate the inexorable working of economic laws, they fall an easy prey to political agitators. Everywhere, the problems presented are difficult of solution ; but nowhere are they more complicated and baffling than in our Indian Empire where, to the world-wide disturbances caused by the war, are added those due to the partial transfer of the executive functions to an inexperienced democracy. But this is not all ; there are yet other problems arising from the absence of suitable employment for the growing stream of graduates produced by the educational system which turns out men ill-fitted for the labour market, into which they must be absorbed. The ranks of the extreme political party are largely recruited from the unemployed and from those who are unable to find work of the character to which, they consider, they have a reasonable right to aspire, in virtue of their education and attainments.

The market value of a university degree has steadily depreciated during the last thirty years, notwithstanding the efforts that have been made to promote industrial development and expand the field for the utilisation of the services of the educated classes. It was the late Mr. Justice Ranade, of the Bombay High Court, who first drew attention to the necessity for creating in India opportunities for more varied careers than are offered by the administration and the legal and teaching professions. A great diversity of occupations is essential to the wellbeing of a civilised community and a much higher standard of living than that which prevails in India is necessary to provide the demand for services requiring the exercise of trained intellectual faculties. The development of the natural wealth of the country is the only way in which the material condition of the masses can be improved.

The Government of India had always recognised its obligations in this respect; but its policy was dominated by the *lassez faire* ideas of the Manchester school of economics, and its efforts were on restricted lines which, whilst productive of immense results, failed almost entirely to create new conditions under which the people of India might raise themselves to a higher stage of material prosperity. It is true that there has been a great increase in the wealth of the country; but it is concentrated in a comparatively few hands, so that in the great capital cities of India may be seen the extremes of wealth and poverty. This state of things is by no means peculiar to India, but it is probable that the concentration is relatively more intense than elsewhere. The railways opened up the country and facilitated the transport of raw produce, the irrigation works increased the yield of the soil and mitigated the ravages of famine; but the result has been no great improvement in the condition of the people; merely their number has increased with almost alarming rapidity and the pressure on the soil is as great to-day as ever. The irrigated areas are flourishing when measured by the old standards; but the methods of cultivation are little changed and it is doubtful if the yield of the land has increased per head of the population. In the old days, each village was almost a self-contained unit, importing but little from outside and relying for its simple needs upon its own artisans—potters, weavers, carpenters, smiths, chucklers and so on. The improvement of transport has changed this. The ryot now grows crops for a wide market and he grows what, in his opinion, is best suited to his soil and not what he and his fellow villagers require in their homes. Trade has taken the place of village barter and the artisans tend to congregate in localities where conditions are favourable to their business.

Out of the chaotic conditions resulting from the disintegration of the Mughal Empire, law and order was re-established and private enterprise was afforded free scope. Spasmodically, Government directly intervened and rendered assistance. Chiefly its efforts were directed to introduce new crops and resulted in the establishment of the planting industries. Twenty years ago, it was realised that agriculture required scientific study, and departments were formed under the Government of India, the Provincial Administrations and the larger Native States to bring to the cultivators' assistance the resources which modern scientific discovery have placed at our disposal. A long period of experiment and enquiry was the necessary preliminary to practical results. Much valuable work has been done and many problems have been solved; but the area is so vast and the workers are still so few that it may yet be said that, so far, what has been accomplished is little more than an indication of what remains to be done. The difficulty is not so much to bring the results achieved in the experimental and demonstration farms home to the ryots and to convince them that a change in their procedure will be of benefit to them, as to devise ways and means by which, with their extremely limited capital and their small and scattered holdings, such improvements as are recommended can be adopted.

To supply the needs of the railways and the army, workshops and factories were started with modern plant and equipment and it is only recently that the history of the Ordnance Department has been told in this room. The Survey of India and the Geological Survey of India have also well and truly laid the foundation on which the future economic progress of the country must be based. In the Education Department somewhat futile efforts have been made to provide courses of instruction and technical training ; we may exempt from this stricture the Civil Engineering Colleges, which have done very good work, and the men who have passed through them now fill some of the highest administrative posts in the Public Works Department and their work, especially in Mysore, will bear comparison with that of their European contemporaries.

At the outset, the vast field thrown open to private enterprise in Industry only attracted the attention of European pioneers save in Bombay, where, in the course of seventy years, a great cotton mill industry has been built up by Indians and this has been followed by developments such as the hydro-electric installations in the Western Ghats and the steel works associated with the Tata firm, which have clearly demonstrated what can be done by capital and well-directed business efforts to place India on a footing of industrial equality with the more advanced manufacturing nations of Western Europe and America. The progress has been good but nothing like fast enough to absorb the energies of the ever-increasing stream flowing from the educational institutions which have been set up.

The position to-day is unbalanced and equilibrium can only be restored by accelerating the industrial re-organisation. This is generally recognised. In 1916, Government appointed an Industrial Commission to review the situation and suggest the measures required to meet the demand for employment and to render the country less dangerously dependent on foreign sources of supply for the essential requisites for its continued existence as a civilised state. The report of that Commission was brought before this Society in a paper by Mr. D. T. Chadwick. Its recommendations have, to some extent, been nullified by the changes introduced into the administration of the country by the Montague-Chelmsford Reform Scheme. The development of industries has been made a transferred subject entirely under the control of the Provincial Ministers and the suggested central organisation under the Government of India has in consequence been abandoned. Private enterprise, however, has been slightly assisted for some years past by the gradual increases in the tariff on imported goods and more recently the question of protection has been examined by a Tariff Committee, the recommendations of which have been accepted by the Legislature. India has definitely embarked upon a protective policy for existing industries which need temporary protection and for new industries which may come to maturity if afforded such assistance at the outset. A Tariff Board has been appointed to advise the Government of India, every application for protection being subjected to public investigation. Whether the result will be commensurate with the expectations, remains to be seen; but it may be admitted that the procedure adopted in examining applications is likely to reduce to a minimum the disadvantages which are thrust upon the consumers when prices are raised, as raised they must be, at any rate for a time, by the operation of protective duties. The problem is complicated by the instability of the rupee, the exchange value of which is now probably below the rate which should be permanently fixed in the best interests of the country. Food prices are much too high, and, as they are controlled by world prices, only a high value of the rupee will bring them down to a reasonable level.

Many of the Indian States have been keen to develop their resources and have not been hampered by rigid adhesion to any economic theories. That, with notable exceptions, they have progressed at a slower rate than in British India is due to their comparative isolation, to a more primitive system of administration, to a soil, in some instances, less fertile and, in other cases, devoid of minerals of commercial value. Two-fifths of the country belongs to them; but they only support one-fifth of the population and, though some are on the seaboard, none possess harbours of any great value or terminal seaports. The smaller States, especially, have been cramped by their limited resources, their lack of transport facilities and their inability to carry out a well-considered development policy till definite results are attained.

These preliminary observations are necessary to form a rough idea of the industrial conditions which prevail in our Indian Empire to-day. A great deal has been done; but the great mass of the people have been only indirectly affected by the industrial movements which are occurring in their midst. The enormous expansion of the external trade has brought the products of the world into every village and has excited new aspirations which inadequate means render it impossible to gratify. The middle classes are those most affected and are those who are most conscious of their straightened means. More by accident than design, the Madras Government were pioneers in what may be termed direct action on the part of the State to improve existing indigenous industries and to introduce new ideas, and the measure of success which attended the working of their plans has encouraged nearly all the other local administrations to follow their lead. There is now a Government Department of Industries in every Province except Bombay, and in a number of the more important Native States. Unfortunately, the importance of the personnel of these Departments is not yet fully recognised, especially in the direction of technical knowledge and practical experience with industrial operations, and in this respect the recommendations of the Industrial Commission have not been carried out. Notwithstanding the financial stringency, comparatively liberal funds have been allotted and it is possible that more would be made available if there was more confidence that results would be forthcoming. The educated people of India recognise and deplore their industrial backwardness, and they are not unwilling to see money spent to bring about improvements; but they have a shrewd idea, at the present time, that in dealing with the problems to handle which falls within the province of the Departments, there is a lack of leadership and driving power, which can only be supplied by men intimately acquainted with the country and possessing experience in applying modern methods of operating to the conditions which exist in India.

These general remarks apply to Mysore equally with the rest of India; but they hardly emphasise sufficiently the prominent part which the Government of the State must play in any movement which requires capital and complex organisation for its development. There are neither great landowners nor great merchants within its borders; neither is there any tradition in favour of co-operative working which would induce that concentration of energy which is essential for the opening up of natural resources very difficult of access. Into the service of the State the élite of the South of India have, in the past, been attracted and though, in recent years, there has arisen a cry of "Mysore for the Mysorean," it is unlikely that it will appreciably affect the State policy which, it is fully recognised, requires for its administration experience acquired in a wider field.

We may now turn to the consideration of the subject of this paper, "The Industrial Progress of the Mysore State," as illustrating the methods by which an Indian administration has endeavoured to solve the problems presented in this preliminary statement.

The State of Mysore stretches from the Western Ghats across the triangular termination of the great table-land of Southern India. It lies between the parallels of 11-38′ and 15-2′ north latitude and covers an area of 29,305 square miles. On the north it is drained by the Tungabhadra and its affluents, on the east by the Pennair and Palar rivers and on the south by the Cauvery. The watershed ridge strikes roughly north-west and has an elevation of 3,000 feet, the country sloping, with many undulations, broken by ranges of rocky hills, towards the great river beds. The State is divided by a line running north and south into two tracts. On the west lies the Malnad or hill country, characterised in the main by a heavy rainfall and a dense tropical vegetation. It is a wild and extremely beautiful country, with a fertile soil but sparsely populated. The incessant monsoon rainfall renders the country unattractive to people accustomed to a dryer climate and there has been but little development except by planters, both European and Indian, who have found its soil and climate suited to the cultivation of coffee. The industry is a very precarious one, the volume of the crops depending almost entirely upon timely rain in the flowering season, whilst the value is subject to very serious fluctuations. The area occupied by the estates is about 110,000 acres.

The eastern and by far the larger tract is known as the Maidan or open country, where the rainfall is much less and more precarious. The surface is highly diversified by irregular ranges of hills and by occasional lofty isolated masses of rock. The characteristic feature of the country is the vast number of tanks or reservoirs which have been formed by throwing earthen bunds across the drainage courses, behind which the rainfall is stored for the irrigation of the crops. In every river valley, there is a chain of such tanks, each surplussing into the next one lower down and occasionally, after cyclonic rain, serious floods are caused by the bursting of the bunds of a whole chain of tanks. These tanks number over 30,000 and vary in size from ponds irrigating a few acres to large lakes, which, when full, cover an area of many square miles. Most of these tanks are very ancient works, but, since the establishment of the Public Works Department, some very large reservoirs have been formed by the construction of masonry dams, notably that at Marikanve, which forms a lake over 30 square miles in area, and at Kannambadi on the Cauvery river, where the dam will be, when fully completed, 124 feet high and will rank among the great masonry structures of the world. The rainfall decreases from west to east, and over the whole State averages 30 inches. In the Malnad, on the edge and slopes of the Western Ghats, it is extremely heavy, ranging from 200 to 300 inches per annum; over the rest of this region, it is much less, varying greatly with the configuration of the land ; probably 60 inches may be taken as a fair average. In the Maidan area, it falls in the east to less than 20 inches per annum.

Geologically Mysore is one of the oldest land surfaces of the globe, and its superficial configuration is entirely the result of sub-aerial denudation. The soil and sub-soil are due to the disintegration of the Archaen and Plutonic rocks *in situ* and only to a limited extent in the valleys is the surface soil formed by fluvial deposits. The mineral wealth is considerable and the Kolar Gold Field is well known. Its phenomenal success has stimulated prospecting throughout the State and has furnished the Durbar with means to establish a regular Geological Survey, which has steadily worked out the geology of the State during the last thirty years. Gold has been found in many places, but nowhere outside the Kolar area in paying quantities. Manganese, chrome ore and iron ores are all worked on a commercial scale and, in a smaller way, magnesite, asbestos, corundum and mica are the basis of successful commercial undertakings. The total exports of manganese ores are 603,874 tons, of chromite 168,339 tons and of magnesite 14,000 tons. The geological structure of the plateau precludes the hope of ever finding coal deposits ; but that handicap to industrial enterprise has, in part, been overcome by the utilisation of some of the available water-power.

Of the total area of the State, a little more than one-third is under cultivation, of which nearly 900,000 acres are under irrigation, the figures for 1921-22 being as follows :

Government canals	117,250 acres.
Private canals	1,789 ,,
Tanks	519,654 ,,
Wells	69,949 ,,
Other sources	187,558 ,,
Total	896,200 acres.

Of the irrigated crops, rice (700,000 acres) is the most important, followed by sugarcane (40,000 acres), mulberry (35,000 acres), and miscellaneous garden produce to make up the balance. The dry cultivation is chiefly devoted to food grains (5,500,000 acres) of which *ragi* is the most important. Oil seeds including castor, gingelly and groundnut, occupy 300,000 acres, cocoanuts 125,000 acres, coffee 110,000 acres, cotton 120,000 acres and tobacco 20,000 acres. Only round figures can be given, as the statistical returns are not very accurate and the areas under cultivation fluctuate greatly from year to year, depending upon the character of the season. Failures of crops due to insufficient rainfall are frequent in the eastern part of the State and, from time to time, severe famines occur. Since the great famine of 1876-78, owing to railways and a better system of famine administration, periods of scarcity have not entailed loss of life on a wholesale scale. To-day they merely present an unemployment problem of a serious character.

The reserved forests of Mysore extend over nearly 2,500,000 acres and are chiefly situated in the Malnad area. On the Ghats and below them is a belt of evergreen forest gradually merging eastwards into deciduous forests. Bamboos cover large areas and are one of the most valuable of the forest products. In the Maidan, the forest areas are of less importance and the trees are of somewhat stunted growth ; but in the Bangalore and Kolar districts there are extensive plantations of *Casuarina*, chiefly grown for fuel. The annual increment is large and the plantations are a very good investment to their owners as the wood realises Rs. 13 to Rs. 14 a ton in Bangalore at the present time. The State possesses a fully equipped Forest Service modelled on those of British India, and derives a considerable net revenue from the forestry work. To a large extent, this is due to the Sandal Tree, the possession of which is a State monopoly. By distillation, the heart-wood and roots yield a valuable oil. Of late years there has been much greater activity in extracting timber, for which saw mills have been set up. Nearly 100,000 tons a year are now being converted into charcoal in by-products-recovery kilns at the Bhadravati Iron Works, to which reference will be made later. The gold mines at Kolar require over half-a-million cubic feet of timber for props, the bulk of which is still imported into the State, chiefly from the forests on the West Coast. A good supply of fuel is of great importance in Mysore since coal can only be obtained from Bengal or the Hyderabad State ; even so it is scanty and dear, due to the lack of adequate means of transporting it from the forests. The fuel problem can only be solved by the encouragement of extensive plantations along or near the railways and one would imagine that the high prices which have prevailed for the last seven years would be a sufficient stimulus, but there is still a lack of initiative and capital. It may be taken that from 10 to 14 years are required to bring a *Casuarina* fuel plantation to maturity, and there are not many who can afford and are willing to wait so long a time for a return on their capital, even though that return be an exceedingly good one.

The history of Mysore becomes important when Hyder Ali usurped the authority of the Hindu Raja and commenced his career of conquest, which, at one time, seriously threatened the comparatively weak establishments of the East India Company on the Coromandel Coast. His son Tippu proved even a greater menace, and the wanton disturber of the peace of Southern India ended his career at the siege and capture of Seringapatam in 1799. Mysore was handed back to the recognised heir of the old ruling family and its boundaries, as they now exist, were then fixed, with minor adjustments in 1803. The new Chief was but a child of five and till 1811 the State was governed by one Purnaiya, who was both Dewan and Regent. In that year, being 16 years of age, the young Maharaja took the Government into his own hands, which proved anything but capable, and, twenty years later, it was necessary to depose him and place the administration of the State under a British Commission, the Maharaja remaining in his capital for the most part on friendly terms with the single Commissioner, Sir Mark Cubbon, who from 1834 to 1861 administered the State with singular tact and ability. In 1867, it was agreed to restore the State to the old ruling family; as the adopted heir was only five years old, the British Administration was continued till 1881, when by an Act of Rendition the young Maharaja was placed on the throne of his ancestors and endowed with full powers. Under a succession of able Dewans as chief executive officers of the Maharaja, the traditions of the British administration have been maintained and the progressive policy of the Commission continued, with the result that all traces of the mal-administration of the earlier period have been eliminated and the State has enjoyed many years of steady progress and development. At the end of 1894, the Maharaja, Chamrajendra Wodeyar, died of diphtheria in Calcutta and a career of great promise came to an untimely end. His son and heir, Krishna Raja Wodeyar Maharaja, was only ten years old, and, during the minority of eight years, his mother filled the highest position in the State as Maharani Regent. In 1902, the Maharaja was installed on the Gadi by the then Viceroy, Lord Curzon, and in 1921, as a mark of appreciation by the paramount power, of his able conduct of affairs, the Act of Rendition was replaced by a treaty, thereby enhancing the prestige of Mysore among the Native States of India.

It is outside the province of this paper to deal with other than the economic aspect of the administration; but, as will be seen later, that affords ample evidence of a wise and far-seeing conduct of affairs on strictly constitutional lines, as prescribed first in the Act of Rendition and re-affirmed in the later treaty. In the early days of the Commission the revenue was about Rs. 70,00,000 a year; that it is now Rs. 3,35,00,000 is some indication of the progress that has been made. The estimated population at the beginning of the nineteenth century was about 2,000,000; at the first regular census, taken in 1871, it was slightly over 5,000,000. The great famine probably reduced it by nearly 1,500,000, followed for a time by a rapid recovery; but during the last twenty years, the increase has been comparatively slow, due, possibly, to the ravages of plague in the earlier years and to the great influenza epidemic of 1918. The 1921 census returned the population as 5,978,892. It may be taken as certain that, under present conditions, although little more than one-third of the State is under cultivation, population cannot much further increase without reducing the standard of existence.

The future of Mysore, and indeed of India, rests with the success of measures to improve the methods of agriculture; yet it is far from being recognised that, whilst it is important and highly desirable that India should be rendered more self-contained and less dependent on imported manufactures, it is absolutely essential that the land should be made to yield more produce and crops of a higher value than are now grown. Agriculture is the great industry of the country, and manufactures must depend on it. The British Isles, Japan and, to a lesser extent, certain European States may, by virtue of their geographical position and by the high intelligence and technical skill of their people, be able to live as manufacturing nations; but for India to strive after such a position is hopeless, and any policy to encourage industries in the country should be based on a recognition of the supreme importance of providing in the country every possible facility for bringing to the land the resources of mechanical engineering and chemical and physical science, with a view to their utilisation to increase the output and extend the margin of cultivation.

Indians have no need to increase and multiply, for there is no land to replenish. The population is big enough, and it is time we ceased to count heads as a mark of progress; and, instead, began to examine more carefully the standards of living enjoyed by the great mass of the people. Fortunately, even without a policy, the pressure of circumstances has forced individuals more or less to work in the right direction; but when the Government intervenes to help the individual, a definite policy is necessary, and it should be possible to state clearly what ends are to be achieved by the pursuit of that policy. The mechanical engineer has made America, and mechanical engineering is wanted in India, not only to supply the mill industries, the railways, the mines and the miscellaneous factories with equipment, but also to supply improved implements and tools for working the land, pumps for lifting water for irrigation and machinery for preparing the crops for the market. A very great deal has been done; hand spinning was dead till Mr. Gandhi revived the *charka* as a criterion of political capacity and as a protest against the tendencies of the age; rice hulling by the primitive methods of pounding the paddy is still carried on and large quantities of wheat are ground in hand querns; but the numbers engaged in these occupations have greatly diminished and mills, large and small, driven by steam, internal combustion or electric motors have replaced them. The excessive sub-division of the land* and the scattered nature of each ryot's holdings, combined with an entire lack of capital for improvements, are almost overwhelming obstacles in the way of establishing a better state of things, and the changes which will have to be made should be the subject of study and experiment by the ardent patriots who think that it is time we handed over the country to them. They are anxious to have a voice in the Councils of the world and to furnish evidence that they are original thinkers and scientists; yet few of them have taken the trouble to study the every-day needs of the cultivator or turned their subtle intellects to solving the problems which must find solution if the teeming millions of India are to be raised in the social scale and placed beyond the risk of privation and want.

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*Attention may be drawn to the valuable work of Mr. Calvert, the Registrar of Co-operative Societies in the Punjab, in connexion with the consolidation of holdings. In a paper read at the Indian Economic Conference in 1923, Mr. Calvert stated that in 126 villiages, 35,000 scattered fragments of land had been consolidated into 4,500. The evils arising from fragmentation are discussed in detail in that paper.

At the time of the Rendition in 1881, Mysore possessed 55 miles of broad gauge and 58 miles of narrow gauge railway; proposals for extensions were in hand and, steadily through the lifetime of the first Maharaja, railway construction was carried on. At the time of his death, in 1894, there were in the State 68 miles of broad gauge and 407 miles of metre gauge railway. Then followed a long period of inactivity, and railway construction was only resumed in 1913. Since then, there have been added to the railways 124 miles of metre gauge, 102 miles of 2′ 6″ gauge besides narrow gauge mineral and forest tramways to the extent of 126 miles. The policy pursued is open to criticism in that it introduced unnecessary breaks of gauge and that the cost would not have been any greater if light metre gauge lines had been laid down in place of the narrower gauges, whilst, by suitable speed limitations, it would have been possible to use the whole of the rolling-stock on any portion of the railway system. During this period, it was considered desirable to establish a State Department of Railways, to work not only the newly-constructed lines, but also such sections of the older lines as the Madras & Southern Mahratta Railway Company could conveniently hand over. The negotiations resulted in the transfer to the State Department of all the railways except those which form essential links in the Madras & Southern Mahratta Railway system. When the working agreements regarding these sections terminate, it is presumed that they also will be taken over to form part of the State Railway System and so, ultimately, Mysore will be independent of outside assistance in this important branch of public service. From a financial point of view the change has worked unfavourably, as the system is too small, and time is necessary for the State officers to acquire practical experience in railway management. The desire to be independent is, however, one to be encouraged and its realisation is perhaps worth the price that has to be paid.

Mysore has no direct outlet to the coast and, for some years, attention has been directed to the little harbour of Bhatkal in the North Kanara District of the Bombay Presidency. Plans and estimates have been prepared to extend the metre gauge line from Shimoga down the Western Ghats and improve the harbour, so as to make it secure against the south-west monsoon; but the question of ceding British territory, since the Mysore boundary is ten miles from the coast at this point, has prevented any progress with the scheme. Moreover, it is likely to prove a very costly one, which even the most sanguine estimates of prospective traffic cannot justify.

There is no evidence that would materially differentiate Mysore from other parts of the South of India in respect to the condition of its indigenous industries under its native rulers. The numerous tanks, the Cauvery channels, the old temples, the ruined forts and many archæological remains testify to the fact that in ancient times the Mysore plateau was inhabited by people enjoying a fair measure of prosperity and well versed in the arts and crafts which supplied the simple wants of a rural population and gave expression to their religious feelings. It is, perhaps, difficult to-day to realise how little industry and agriculture were affected by the constant feuds and petty wars of the various Chiefs who ruled the land. The artisan possessed but few tools and those of a simple nature easily hidden or, if destroyed, easily replaced. Production was on a cottage scale, and, except in the forts or palaces of the rajas and zamindars, there was little display of wealth and little for the wandering bands of marauders to seize or destroy. Arms and equipment were of the utmost importance and the trades of the iron smelter, the smith and the armourer flourished. Mysore was celebrated for its wootz steel and it is claimed that it was in demand as the material from which the Damascus swords were made. Each village had its own artisans and the more clever and skilled men were attracted to the Courts of the local rulers, where they plied their trades to supply articles of luxury and beauty. During the usurpations of Hyder Ali and Tippu the country suffered badly, and forced labour was ruthlessly requisitioned for the construction of military works. Wholesale migrations took place and when the Arasu family was restored to power and influence, in 1799, the country was in a terrible state.

It is a common impression that the indigenous artisans in India have suffered severely from the competition of the factories of Europe and that they are to-day in a depressed and decadent state. It is probably nearer the truth to state that the reverse is the case and, were it within the scope of this paper, it would be easy to produce convincing evidence that, whilst great changes have taken place and some industries have died out, yet on the whole the artisans are far more numerous than they ever were before, that they turn out a much greater volume of work and that they have adopted many improvements in their methods of working. This is true of Mysore as of other parts of India.

By far the most important of the artisan industries in the State is handloom weaving in cotton, wool and silk. The looms number about 37,000 and the annual value of the outturn is estimated at three crores of rupees. During the Muhammadan usurpation in the latter half of the 18th century the old artistic industries were neglected, and only a few have survived in a degraded state the long period of recuperation which followed. It cannot be claimed that recent efforts to revive them have met with any great success.

Modern industries, apart from minor ordnance factories, were slow in making their appearance in Mysore. The first attempt was the Ashtagram sugar works, which were established in 1847 at Palhalli, near Seringapatam. The object was to refine the jaggery made from sugarcane grown by the local ryots. The scale of operations was considerable and the plant was said to be capable of turning out 2,000 tons of sugar per annum; that it did so cannot now be ascertained. The factory certainly worked for a long period, but was eventually closed down. Later, Messrs. Arbuthnot & Co. established at Goribidnur a similar factory, which has passed through many vicissitudes; it is also now derelict, though it was in operation a year or two ago. The next venture seems to have been a silk filature, with 80 basins worked by steam, which was started in 1866 at Kengeri by an Italian, one Signor Vecchi, who, to improve the local sericulture, imported eggs from Japan. It was apparently a well-conceived scheme, though in the end nothing came of it. In the early eighties, cotton spinning was introduced into Bangalore and two mills were started, one by a Bombay firm in 1883 and the other by Messrs. Binny & Co., of Madras, in 1884. Both were, to some extent, assisted by the Government and both have still Government nominees on their Boards. From comparatively modest beginnings, they have grown to large concerns, which have proved very profitable in recent years. At the present time, the Maharaja Mills have 25,000 spindles and 350 looms and the Bangalore Woollen Cotton and Silk Mills have 35,000 spindles and nearly 1,000 looms. Since the war a third mill with 23,000 spindles has been erected near Mysore with local capital and is now running under local management. Still later, the managers of the Maharaja Mills have commenced building another cotton mill in Bangalore to contain 25,000 spindles and, under Muhammadan management, a new woollen mill near Bangalore has been started.

The recent developments of the textile industry in the Mysore State are no doubt in part due to the favourable terms upon which power is supplied by the Electrical Department of the State. It may be interesting to record that alongside the cotton mill, an oil mill worked by steam power and of modern design was set up; but this venture proved unsuccessful and was ultimately dismantled. The reason for the failure was that local combines raised the price of oil seeds to such a level that operation was unprofitable. Similar difficulties have been encountered not long since by another and even larger enterprise of the same kind on the West Coast.

In the middle of the 19th century the tanning of cow hides with *avaram bark* (Cassia auriculata) was established in the Madras Presidency and the industry also took root in the Mysore State. The Madras Kips are well known in the trade; they are considered to be only half tanned and they are converted into finished leather in the countries to which they are exported. The tanneries of Mysore contribute annually about 40 lakhs of rupees worth of these Kips. The industry is a very simple one and is of economic rather than of technical importance as utilising what was formerly a waste product.

Mention now must be made of the gold prospecting work at Kolar in 1874 by

Mr. M. F. Lavelle, which ultimately resulted in the development of a number of mines now well known all over the world. The story of their early days and of how, when the mining companies were absolutely at the end of their resources, a rich lode was discovered, has often been told and need not be repeated here. The success at Kolar led to prospecting all over the State and to the discovery of gold in many places. Mines were opened up where the prospects seemed to justify it; but outside Kolar none have been successful, and to-day only five of the Kolar mines are now at work. In the year 1923 they produced 422,501 ounces of gold, worth £1,754,895, and paid in royalties to the State £94,860, and in dividends to the shareholders £234,644. The total production of gold up to the end of 1923 has been 15,654,045 ounces, worth £60,387,946, and the royalties received by the State amount to £3,180,722. These mines are now among the deepest mines of the world, and have reached in their bottom workings well below 6,000 feet from the surface. In comparison with the dividends paid to shareholders, the royalties to the State appear to be comparatively small; but account must be taken of the large sums spent in prospecting and in working mines which have ultimately failed. Even among the successful mines, Balaghat which has yielded 609,355 ounces of gold, worth £2,669,868, has paid in royalties Rs. 20,64,286, whilst its shareholders have received in dividends only £317,775.

In view of the fact that there are many in India opposed to the exploitation of the mineral wealth of the country by outside capitalists and desirous of deferring development till it can be undertaken by the people of India without assistance, it may not be inopportune briefly to analyse the working of the Kolar Gold Fields. Up-to-date, the total dividends are 35 per cent. of the value of the gold raised and the share of the State has been 15 per cent. of the dividends; last year the dividends were 16 per cent. of the value of the gold raised, and the share of the State was 34 per cent. of the dividends. The royalties paid are very reasonable, being only 5 per cent. on the gold obtained and 2½ per cent. on the dividends. This latter item has, however, been considerably augmented in recent years by the levy of an income tax. With increasing depth the working costs must increase, and the share of the State which is mainly based on the gross yield steadily becomes a larger proportion of the profits, so that ultimately the whole of the profits will go to the State, unless the terms on which the mines are leased are altered. The fallacy in the Indian argument against working mines with foreign capital lies in the failure to recognise the importance of the loss which India sustains through receiving no interest on capital which lies buried. The wealth of the Kolar Gold Fields is by no means exhausted and each year adds to the share of the profits which the State receives.

But the direct contribution is by no means the only advantage the State has received from the mines. Where there was formerly a barren waste, there is now a flourishing mining settlement, with a population, in 1921, of 87,682. It was the demand for power at the mines which rendered it possible to start the hydro-electric generating station on the Cauvery, the subsequent development of which has done so much to increase the wealth of Mysore. In 1923, the mines used 124,645,672 k.w., for which they paid Rs. 27,96,447. They have greatly benefited by the cheap supply of electric energy, as has also the State in utilising a natural source of wealth which otherwise would have been neglected.

In the early nineties, there was considerable discussion in Madras over the potential water-power of the Periyar irrigation project and a report issued by the Secretary of State drew attention to the facilities for long-distance transmission. Naturally other possible sources of water-power were examined and proposals were made to the Dewan of Mysore, Sir K. Seshadri Iyer, regarding the utilisation of the falls of the Cauvery at Sivasamudram. Captain A. J. de Lotbiniere suggested that the State should undertake the development of the power and find a market for the same on the Kolar Gold Fields. After lengthy negotiations, the project was approved by both parties, and the Government undertook to supply 4,000 h.p. to the mines by a transmission line 92 miles long. Six units of 750 k.w. capacity were installed, worked by turbines on a head of 380 feet. The first motor on the Kolar Gold Fields was formally set in motion on the 16th of August, 1902, by the Viceroy, Lord Curzon, and from the outset the plant worked very well. This was the first long-distance transmission line in India and, at the time, was one of the longest in the world. Two years later five additional units were installed and power to Bangalore City, 57 miles from the generating station, was supplied in August 1905 and to Mysore, 37 miles distant, in 1908. A third installation was added in 1908 and then, for eight years, nothing further was done as the available water supply in the hot weather was fully utilised. To supplement this and to provide for a larger area of irrigation, a great scheme was sanctioned in the Public Works Department in 1912 to build a dam across the Cauvery a few miles above Seringapatam to hold up a very large volume of water. As the storage capacity became available additional units were added in 1916 and 1918 and finally, in 1919, plans for overhauling the power station completely were sanctioned, the original small units of 750 k.w. being scrapped and six new generators of 3,000 k.w. each provided for. When the work is completed, the capacity will be 24,000 k.w. For the year ending June, 1924, the gross receipts were Rs. 44,81,000 and the working expenses Rs. 14,53,000; after allowing 4 per cent. on the capital outlay, the net return was 13.48 per cent. From the beginning, the capital expenditure has been Rs. 175,47,000, the gross income has been Rs. 489,53,000 and the total working expenditure Rs. 187,04,000. The power is supplied to Kolar Gold Fields at special rates. For lighting in Bangalore and Mysore, the rate is four annas per unit and power is supplied on a sliding scale beginning at two annas per unit for a demand of less than 20 h.p., decreasing to 0.6 annas per unit for loads of over 300 h.p., whilst the mills are supplied at only 0.5

annas per unit. These are low rates, especially for power, and the demand in this direction has steadily increased.

The Government pumping stations supplying water to Bangalore, Mysore and the Kolar Gold Fields are now worked by electricity. Besides the mills and one or two other large users of power, there are nearly 150 small consumers with an aggregate load of 800 h.p. The day load is now equal to the full capacity of the generating station, and there are prospective demands for at least one-third more power. This chiefly comes from the mines, which, with increasing depth, need more power for haulage and ventilation. Mysore is fortunate in thus being able to develop its water-power and find an immediate profitable market for it. When, at some possibly distant date, the mines one by one cease to operate, for the power then relinquished other uses will undoubtedly be found, if the policy of encouraging the development of industries be steadily pursued.

As already stated, Mysore has a Geological Department which was first organised in 1895 by the late Mr. Bruce Foote and Dr. S. W. Evans. Some years later, it was reconstituted under Dr. F. W. Smeeth as the Department of Mines and Geology. In 1917, this Department was split in two to deal separately with "Geology" and "Mines and Explosives." In the earlier years attention was concentrated on the geological survey of the State, the work done being recorded in a valuable series of departmental publications; since 1915 greater attention has been paid to economic work with a view to the exploitation of the mineral resources of the State. The economic results of this survey and of all the prospecting work undertaken by private agency are fully described in a hand book entitled the "Mineral Resources of Mysore," issued in 1916 by Dr. F. W. Smeeth.

When the late Mr. J. N. Tata first offered to provide an endowment for scientific research in India the then Dewan of Mysore, Sir K. Seshadri Iyer, anticipating that great advantage would accrue to the Mysore State from the location within its borders of the Institute in which the work would be carried on, drew attention to the suitability of Bangalore on account of its climate and promised a site, a large capital grant and an annual contribution to the income to secure this result. In the end after prolonged discussion on the merits of alternative sites, the Indian Institute of Science was established in 1911 at Hebal just outside Bangalore as a post-graduate University institution, having for its particular object the promotion of advanced studies and original research with special regard to the educational and economic interests of India. In the 14 years which have elapsed since the Institute was opened, many Indian graduates have received a training in scientific method and have been equipped with the knowledge and experience which have enabled them to obtain positions of responsibility in various branches of industrial activity. There is no doubt that its proximity to the centre of the Government of Mysore has proved of considerable use to the State, though perhaps not to the extent that its resources are capable. Three industrial ventures each of which has attained commercial success, were started in Bangalore with the help of the scientific staff of the Institute. In each case, the preliminary work was done in the laboratories of the Institute and, as the author was responsible for initiating the experiments, he can state with some authority that, if the Institute had not been available for the preliminary work, nothing in this direction would have been done. The main object of the Institute, in which it has been eminently successful, is to train men to conduct investigations in a scientific way by employing them on suitable research work. In addition, the Institute may be regarded as a finely tempered instrument for assisting industrial development; in that capacity, however it cannot work alone. It may be confidently stated that it requires both experience and skill of a high order on the part of those outside the Institute engaged on such work to make full use of such a complete organisation. Generally, the subjects for industrial research must be brought to the Institute and only occasionally can they originate in its laboratories. This fact is not recognised by the critics of the Institute who demand results that can only be obtained when the value of scientific research as an aid to industrial progress is properly appreciated. Vague statements are often made regarding the innumerable problems that require solution if full use is to be made of India's resources; but few are presented in such a way that practical action can be taken. It is asking too much of the Institute staff that they should discover for themselves the problems presented by the special conditions of industrial enterprise in India.

The Institute possesses well equipped laboratories for research in Organic, General and Bio-Chemistry and in various branches of Electro-technology. Its students are post graduates of the Indian Universities and they come from all parts of India. Very good hostel accommodation is provided for them and the amenities of college life are by no means neglected. Both staff and students play a prominent part in the annual meetings of the Indian Science Congress, over which this year the Director, Dr. M. O. Forster, F.R.S., presided.

We now come to a period in the history of Mysore which has been, and still is, the subject of some controversy. Hitherto, the State had progressed on normal and very safe lines. There was a large surplus in the Treasury and general contentment with the existing conditions. There is no doubt there was a slight tendency to stagnation and perhaps, as typical of the situation, it may be mentioned that there was some anxiety as to the future, when the mines might be worked out and their demand for hydro-electric power would have ceased. In this calm atmosphere, a man of unusual energy appeared, gifted with imagination and ability to express his ideas and imbued with an ardent desire to serve his country and his native State. It was in 1909 that Mr. (now Sir) M. Visvesvaraya returned to Mysore as Chief Engineer. He had served in the Bombay Public Works Department with distinction and had travelled widely. From the outset, he made himself a force in the State, and to his initiative was due the establishment of an Economic Conference to meet once a year, and to carry on work continuously, of three Central Committees for (1) Industries, (2) Agriculture and (3) Education, and of eight District Committees presided over by the Deputy Commissioners, the functions of which were to apply locally the results of the deliberations of the Central Committees and to gather and forward to these bodies information regarding local possibilities of development and local needs. Later, an attempt was made to form Village Committees but with only a scant measure of success. All the leading men in the State, official and non-official, were persuaded to take an active part. Meetings of the Committees were held monthly to discuss long programmes drawn up by official secretaries. Departments of Agriculture and Education already existed, and, early in 1913, one to deal with Industries was created. In 1912, Mr. Visvesvaraya was appointed Dewan and took up the office imbued with the idea that Mysore should lead the way in India in the development of its resources and in the improvement of the moral and social condition of the people. For seven years he laboured incessantly; but the times were against him and the war, which broke out before he had been two years in office, seriously interfered with the progress of his plans. The important developments in railways and the generation of electric energy have already been mentioned. At the beginning of his period of office, recognising the need for improved banking facilities in the State, he took measures to establish what is now known as the Bank of Mysore, which, under its first Manager, Mr. W. C. Rose, has been of great assistance to the commercial community during a very trying period.

In pursuance of the idea that the State possessed adequate resources to maintain its own institutions for the promotion of culture, the University of Mysore was founded and, later, a school for the training of mechanical engineers.

In 1917, after consulting Mr. C. P. Perin, the Chief Engineer and technical adviser of the Tata Iron & Steel Company, the Mysore Government were committed to an extensive project to utilise the forests in the north of the State to supply charcoal for smelting the iron ores of the Bababudan Hills. Forest areas were reserved to yield annually 100,000 tons of wood on a thirty years' rotation and a wood distillation plant provided so as to secure all the valuable by-products of charcoal manufacture. The scale of operations contemplated an outturn of 20,000 tons of charcoal iron a year. The works were constructed by the Tata Iron & Steel Company and have now been in operation for two years. The author is not in possession of accurate data regarding the results achieved; but it is common knowledge that the capital expenditure is in the neighbourhood of 200 lakhs of rupees and that so far the running costs exceed the value of the iron produced. Interest charges and depreciation add at least Rs. 100 per ton to the total cost. A time must come when heavy repairs and renewals will have to be faced and it would seem that then of necessity this unfortunate enterprise will have to be shut down.

In the newly-created Department of Industries, of which the author was in charge for nearly four years, work was mainly concentrated on the encouragement of the use of small power plants in rural industries. Previous experience in Madras had demonstrated the practical value of such plants, provided discrimination was exercised in the selection of suitable applicants for assistance. Similar results were obtained in Mysore so long as it was possible to obtain the requisite machinery and many oil engines and suction gas producer plants were set up to drive pumps to lift water for irrigation, to drive sugar cane mills, oil expellers, saw mills, rice hullers and miscellaneous machinery. The necessity for a liberal measure of State Aid was recognised and rules were drafted which received the sanction of Government for the grant of State loans, known in India as Taccavi advances, on the security of land and of the improvements to be effected by the loans, and of advances for the hire-purchase of machinery and plant. These have proved useful and, recently, the Madras Legislature in their " Aid to Industries Bill " have adopted similar methods to attain the same ends, though, as it is now contemplated to grant much larger loans than are permissible in Mysore, more elaborate machinery has been devised for the preliminary investigation of applications.

The first industrial aid rendered was to a chrome tanning company started by an Assistant of the Department of Industries in Madras who had been in charge of the pioneer chrome tannery. One-third of the capital was contributed by Government and a venture which would certainly have collapsed from want of funds was rescued to contribute materially to the technical advancement of tanning in India, though perhaps with less profit to the shareholders than they deserved. It is significant that at the present time the tannery is being worked by an European agency firm in Madras.

An experimental weaving shed was started and the manufacture of simple warping mills, framed looms and fly shuttle sleys undertaken. Peripatetic weaving parties under competent instructors were sent to the more important weaving centres and the weavers given instructions in their own homes. It is estimated that 6,000 or nearly one-third of the cotton weavers in the State have taken to the use of the fly shuttle and have thereby increased their weaving capacity by at least fifty per cent. Experience however seems to indicate that this increased capacity is not utilised and that, in consequence, the economic effect of the change is but slight. The strengthening of one link in a chain is useless unless it be the weaker.

Experiments in the manufacture of soap were initiated and eventually a small factory was started which has steadily expanded and is now a considerable commercial success.

Later, under Mr. Rungasawmy Iyengar, the second Director of Industries, modern metal working for the production of copper and brass hollow-ware was introduced and the resulting factory has been taken over by a private company.

The area under sugar varies greatly from year to year, being dependent on the rainfall and the amount of water in the tanks. Ryots usually cultivate only small patches, as they have neither capital to grow a larger crop nor cattle to crush the canes from large areas. The Department set up a number of small power driven mills, each capable of crushing an acre of cane (20 tons) a day with improved arrangements for boiling down the juice. The ryots in the neighbourhood of these plants were invited to bring their cane to be crushed and the juice converted into jaggery and were charged a fixed rate per maund of jaggery produced. The response was, in some places, fairly good; but it was always inadequate and irregular. The mistake was made in not buying the cane and relieving the ryots of the anxiety of disposing of the jaggery. If this had been done, it now seems probable that these plants would have met with much greater appreciation and that the area under cane would have increased in their neighbourhood. The power driven mills obtained a larger percentage of extraction and the improved boiling yielded a better quality of jaggery. It is desirable that the experiment of buying the cane in selected areas should yet be tried. The work on sugar cane crushing has, nevertheless, borne useful results, as power driven mills are gradually coming into use in those parts of India where the conditions are favourable, and it seems certain that as the iron roller mill displaced the wooden mill, so the power driven mill will replace the use of cattle. Most of the cane grown in India is converted into jaggery, which is still the favourite form in which sugar is consumed by the people, though the taste for sugar is growing, fostered by the fact that the excess requirements of the people can only be supplied in that form. The imports into India are very large, and it is noteworthy that even now India grows enough cane to supply its own needs; but it wastes at least one-fourth of the supply through imperfect extraction. This wasted sugar is burnt with the megasse under the boiling pans.

A more successful venture has been the distillation of sandal-wood oil. The tree flourishes over a comparatively small area in the South of India, the greater part of which lies within the boundaries of Mysore. It is a State monopoly and has always been an important source of revenue. In 1880-81, 1,443 tons of sandalwood were sold for Rs. 5,18,000 or Rs. 387 per ton. In 1911-12, 2,363 tons were sold and realised Rs. 12,59,301 or Rs. 534 per ton. In the next two years extraordinary rates were obtained at the annual auctions, as in 1913-14, 2,147 tons were sold at an average rate of Rs. 1,051 per ton. The war intervened and, at the next auctions, no wood was sold. It then seemed to be a favourable opportunity to abandon the system of disposing of the wood by auctions and the Director of Industries suggested experimental work in the distillation of the wood with a view to selling the oil instead of the wood. This was sanctioned and, in conjunction with Messrs. J. J. Sudborough and H. E. Watson, two of the professors of chemistry at the Indian Institute of Science, distillation on a laboratory scale was tried and from the experience gained, plans were prepared for a factory to turn out 2,000 lbs. of oil a month. There were difficulties connected with the equipment, owing to the war, and everything had to be made locally. In May, 1916, the factory started distilling sandal-wood. In a short time, additional steam plant and stills were added and, by the end of the year, the output was raised to 6,000 lbs. a month and the erection of another and much larger factory in Mysore undertaken, which started distilling wood in September, 1917. Whilst the export of wood was difficult owing to the war there was a considerable demand for oil notwithstanding the fact that enemy countries and Russia were out of the market. The factories have proved a commercial success as, with a total capital outlay of Rs. 7,00,000, by June, 1924, a net profit of Rs. 27,00,000 had been made. Up to that date 850,000 lbs. of oil had been sold for Rs. 1,90,00,000, equivalent, at the fluctuating rates of exchange during that period prevalent, to £1,500,000. The sandal-wood of the Madras and Coorg Forest Departments is still sold by auction and it is estimated that, during the same period, the receipts on this account are less by Rs. 22,00,000 than they would have been if the oil had been distilled and sold in place of the wood. These sandal-wood oil factories, like the turpentine factories at Jalloo and Bhowali in the North of India, are favourable examples of the direct exploitation of the forest resources by Government agency.

The establishment of this industry in the State has given rise to an essential oil industry of considerable promise, started by Mr. B. Seetharam Char, who was formerly the senior technical assistant in the Government Factories. Besides distilling oils from local products, raw materials are imported from various sources of supply bordering on the Indian Ocean. This branch of the business is however handicapped by the revenue import duties, which undoubtedly ought to be abolished.

Independently of the Department of Industries, sericulture has been revived and modern granaries established to supply disease-free seed to the rearers. The silk industry was introduced during the Muhammadan usurpation in the time of Tippu. The worms are poly-voltine and six or seven crops a year can be obtained; but the cocoons are much smaller than those of uni-voltine worms. The mulberry in Mysore is a shrub and not a tree and it is usually irrigated. The indigenous methods of silk reeling are clumsy and inefficient. Attempts at improvements have been made from time to time with little success. Quite recently, however, a French filature has been set up in Mysore which turns out excellent silk and it seems likely that private enterprise will establish others. The published statistics of the silk industry are very unreliable, so that it is difficult to estimate what is the annual production. The agricultural statistics exhibit improbable fluctuations in the area under mulberry and the rail-borne trade returns are of little use as they include large imports into Mysore by road from the adjoining district of the Madras Presidency for transport through the State by rail. Roughly, it seems likely that Mysore produces about Rs. 100,00,000 worth of silk per annum.

It would be easy to burden this paper with a vast amount of statistics; but they would be of little more than local interest. Since the system of making Taccavi loans for industrial purposes was introduced, about Rs. 9,00,000 has been advanced, of which Rs. 4,77,255 has been recovered and Rs. 90,537 paid by way of interest. Independently of Government, upwards of Rs. 8,00,000 has been invested in these small industries in the last two years, and though these sums may seem trifling to European industrialists, they indicate a growing movement in the right direction. Perhaps of more interest are the figures for the total import of machinery into the State, which are as follows:

1920-21	Rs. 57.44 lakhs.
1921-22	96.69 „
1922-23	85,52 „

Reference has already been made to the Dam constructed across the Cauvery at Kannambadi. On this work at the end of 1924, the expenditure had been Rs. 217 lakhs and to complete the work to the full height a further outlay will be necessary. Primarily, it was constructed in connexion with the hydro-electric scheme; but the ultimate storage capacity will be much greater than that required for power developments; so it will be possible to divert a large amount of water for irrigation in the Mysore State. This has caused great alarm in the delta tracts of the Cauvery, where an extensive area of rice cultivation depends upon the flow of the river, and the project of the Mysore State has been the subject of very prolonged negotiation with the Madras Government, finally resulting in a settlement, whereby Mysore is allowed to complete the storage works and to irrigate an additional 1,25,000 acres. The industrial future of Mysore will be largely influenced by the way in which this concession or right is exercised. The irrigation works may be carried out from surplus revenues, and therefore slowly and with heavy accumulations of interest before any return is obtained, or they may be executed rapidly with borrowed money and designed to secure the greatest possible return. Usually, irrigation in the South of India connotes paddy crops and it is likely that this will be the case under the Kannambadi reservoir unless special efforts are made to assist the cultivators to grow sugarcane. It is a crop which requires capital and the provision of adequate machinery to deal with the cane when it is ripe. The area mentioned should easily produce 1,000,000 tons of cane a year, to handle which mills having a daily capacity of from 7,000 to 8,000 tons of cane will be required. The yield of sugar should be at least 100,000 tons a year, worth about Rs. 400 lakhs. As India imports about four times this quantity, there is an assured home market, which, at the present time, is protected by a tariff of 25 per cent.

The area of waste land in Mysore is very extensive and much of it can never be brought under cultivation; but there are almost certainly large tracts which could be utilised very profitably for fibre plantations. The Department of Industries, at a very early date, collected all the available information regarding the growth of sisal hemp in the State and issued a bulletin on the subject. Here and there, a few plants have been grown with good results; as yet, no well considered attempt has been made to establish plantations on a commercial scale. There is now no doubt that where there is sufficient lime in the soil, an important proviso in an area which has never been submerged and which therefore contains no marine deposits, the plant will grow well except in the more arid parts of Mysore. Each plantation to be a commercial success must be on a large enough scale to furnish a continuous supply of leaves to keep at least one of the modern fibre extracting machines at work. Such a machine will turn out two tons of fibre per day and as the fibre is about four per cent. of the leaf, the supply should be about 50 tons a day, equal to the yield of four acres closely planted. With 300 working days in the year, a minimum area of 1,200 acres is indicated. Regular plantations involve a large capital outlay, which might be avoided if only the villagers in sufficient numbers could be induced to plant small areas of sisal hemp. With the fibre at £40 or roughly Rs. 500 a ton in London, the gross value of a ton of leaves is Rs. 20 and allowing half the gross value for extracting the fibre and putting it on the market, the ryot should get Rs. 10 a ton for his leaves or Rs. 125 per acre, about three times as much as he can hope to get from his land with any other dry crop. Of course, he will have to wait four years before he can begin to harvest leaves, and that he cannot do; at any rate, it would be impossible to get a sufficient number within a reasonable distance, say five miles of a central factory. It is therefore a matter for the Government to take up and this is now engaging the attention of the Agricultural Department. The justification for intervention, if any is needed, is that land almost useless for ragi can be utilised and that, in addition to the crop being a comparatively valuable one, it will be little affected by an unfavourable distribution of the annual rainfall, which is so frequently a cause of loss to the cultivator of food crops. If 100,000 acres of sisal hemp were established, the crop would be worth on the spot Rs. 125,00,000, and as the land occupied would be on or beyond the margin of ordinary cultivation, it would prove an extraordinarily valuable insurance against famine. Concentration of cultivation is essential if such crops as sugarcane and sisal hemp are to be subsequently treated by efficient modern machinery. The ryot will not grow the crops till he is certain that he can dispose of them; the capitalists will not put down the machinery till the crops are visible, and so nothing will be done unless Government can take the initiative and, in the general interests of the community, guarantee the ryot against loss at the outset.

From the foregoing account of the industries of Mysore, it will be seen that the people are emerging from the primitive industrial system that has from time immemorial prevailed all over India. They have not yet acquired confidence in large joint-stock concerns. Except those that have been started recently and have not yet made good, all now working were initiated and are still controlled by managing agencies outside the State. The country is prosperous from an Indian standpoint but in no sense wealthy and the Government alone is powerful enough to take action in any large and important projects. The following table shows that its investments in productive works, excluding those pertaining to irrigation, are of great importance:

Statement of Capital Outlay on Productive Works as on 1st July, 1924.

1.	Mysore State Railways worked by Madras & Southern Mahratta Railway Company	190 lakhs.
2.	Railways worked by the State	279 ,,
3.	Electrical Works	176 ,,
4.	Krishnaraja Sagara Dam on the river Cauvery	217 ,,
5.	Sandal-wood Oil Factories	7 ,,
6.	Iron Works	191 ,,
7.	Other Works	2 ,,
8.	Kolar Gold Fields Water supply project	18 ,,
	Total	1080 lakhs.

Besides these, it administers the reserved forests which yield an average gross revenue of Rs. 16 lakhs a year and a net revenue of nearly five lakhs. It will, therefore, be evident that the Government recognise their responsibilities and have fairly endeavoured to shoulder them. The revenue of the State is perhaps the best measure of its general progress and the following figures for quinquennial periods have some significance in this respect, especially if the comparatively inelastic item of Land Revenue be excluded:

TOTAL REVENUES.

FOR THE QUINQUENNIUM ENDING.	AVERAGE.		
	LAKHS OF RUPEES.		
	Land Revenue.	Other Items.	Total.
1885—86	71	37	108
1890—91	86	51	137
1895—96	92	81	173
1900—01	96	90	186
1905—06	97	115	212
1910—11	101	137	238
1915—16	105	176	281
1920—21	108	203	311
For the year 1921—22	116	196	312
,, 1922—23	118	213	331
,, 1923—24	113	225	338
,, 1924—25 (Budget)	122	214	336

From a condition of benevolent autocracy, the administration has gradually changed its character first by the institution of the Representative Assembly in 1881, then of a Legislative Council in 1886, which was merged in 1923 in a Legislative Assembly endowed with considerable authority. As the Government becomes more popular, it naturally ceases to be paternal and it is likely that in the future, development will rest, much more than in the past, with private enterprise. That the change has occurred too soon, is the opinion of many; but the early assumption of popular responsibility may conduce to a more rapid growth of individual enterprise than would happen by a prolonged retention in leading strings.

DISCUSSION.

THE CHAIRMAN (Sir Thomas Holland) said that the paper had been a sober, well-proportioned survey of the conditions in the Mysore State, and those of them who had worked with Sir Alfred Chatterton in India—and he saw some among the audience—must realise with him that the preparation of a paper of that sort required some exercise of restraining influence on the tendency he must have had to deal with the causes which led to the imperfect fruition of the great efforts he had made when in charge of the industries of the Mysore State. Many of his schemes might and would have developed had Sir Alfred Chatterton still been there to control and guide them. The paper dealt with much more than the Mysore State. The Mysore State had been chosen as an object-lesson applicable to the other provincial units of India. The problem in India now had changed considerably since the Industrial Commission reported, for the provincial spirit had grown up so strongly that schemes for organisation on a large scale had been completely changed, and the provincial units which would now be worked must suffer to some extent from inability to command the resources necessary to deal with industries on a modern scale in competition with technological industries of other countries It was rather painful to see some of these descriptions, especially those that were enumerated about half-way through the paper—industries that were started and obviously had a power of developing, and might have done so if the accessory conditions had been established alongside the main attempt.

There was one sentence in the paper which seemed to the speaker to bring out most clearly one of the very great difficulties attaching to the attempts made to encourage on behalf of the State the development of minor industries in India. It was the reference to the way in which the weaving industry failed to respond to the efforts made to develop it, and the paragraph contained this significant sentence: "The strengthening of one link in a chain is useless unless it be the weakest." That was what was found in all the attempts to encourage industries in India. The success depended very often upon some accessory raw material or some subsidiary process or some way of utilising the by-products. Mysore, like the rest of India, was a land of high lights and deep shadows. It had a flourishing gold-mining industry, completely eclipsing anything else of the sort in India. There was electrical power which had developed in a flourishing way, there was a sandal-wood oil factory, and yet, by the side of these very advanced and well-developed industries, there was a somewhat primitive condition of affairs generally throughout the State. In mineral resources Mysore possessed gold and iron ore in abundance, but no coal. He said "No coal," in spite of the very definite assertions recently made in the newspapers of coal actually being found in Mysore in a boring that passed through a considerable amount of granite before the coal was reached. The discovery was one that, no doubt, had some other explanation which it was not necessary now to detail. In every attempt to develop India's industrial work two great difficulties made their appearance—one, the want of training in technology together with the imperfect information obtainable regarding the raw materials of the country in consequence of the absence of scientific research, and the other the inability of the people in the country still to appreciate the value of banking. Sir Alfred Chatterton's problem in Mysore was to attempt to utilise the ryot in his uneducated state, to turn to account his own methods, to introduce to him machinery of a kind that he could use and easily repair and which was in units small enough to meet his limited resources. In that way Sir Alfred had developed over the State a considerable increase in industrial activity. It was along those lines that the work ought to be continued, because it would be a generation or more yet before the modern industries organised on modern technological lines would be possible for a community of that sort.

The Provinces of India now had certainly taken a direction which showed that they must realise the enormous advantage of scientific research before they developed the natural resources of India. The resources of India, vegetable and mineral, were different from those of other countries, but science was world-wide in its application, and what it had done for the industries in Europe it ought to do in India. Scientific work had been so specialised, however, that the practice so often followed in India of employing two or three men to do scientific work of all kinds was asking for trouble. Unless the scientific man was doing research work along his own special lines he was more likely than not to be a failure. With regard to banking—the other great problem—India was still extremely slow to appreciate the value of having in this way fluid capital. In Mysore State a move had been made of great value in the system produced by Sir Alfred Chatterton, of making small loans to ryots to purchase relatively small units of machinery so as to reduce their labour charges and to bring about better treatment of their crops, and these loans had been made in such a way that they were repayable in easy instalments, and, so far as the speaker understood, the number of failures had been extremely small. The people were thus learning, to some extent, the value of money that could be borrowed at a reasonable rate of interest and under suitable control. The next step, one hoped, would be the utilisation of banks. A bank had been established in Mysore and attempts were being made to establish banks in other parts of India, but the results up to the present were far from satisfactory.

He was glad to see present Sir Ernest Low, who did, in the Central Provinces, the work that Sir Alfred Chatterton was doing in Madras. As a member of the Industrial Commission Sir Ernest had the opportunity of travelling all over India and seeing the industrial conditions. He also welcomed Commissioner Booth-Tucker, who, for the Salvation Army, had carried on work in India, not only with an industrial end in view, but for social betterment.

Sir Ernest Low, K.C.I.E., said that it had been a great pleasure to listen to Sir Alfred Chatterton's paper. He thought the first time he made his acquaintance was at the Allahabad Exhibition in 1911, and the conversations he had with Mr. Chatterton (as he then was) at that time convinced him that he had in him the root of the matter in respect to industrial developments in India—a subject with which he (the speaker) at that period, like many other officials and private persons in India, was deeply interested. He felt that here at any rate there emerged amid the cloud of ink and talk which had hitherto been the only contributions to the solution of the question some definite ideas which could be followed up to give practical results, and from that time he was and professed himself a follower of Mr. Chatterton's ideas and a personal admirer of his work.

He had the pleasure of being associated with him, and with the Chairman of that afternoon, in the report of the Industrial Commission and its preliminary inquiries; he put the report before the inquiries because to some extent it was not so dependent on what the witnesses said as might be imagined. The long hours which Sir Thomas Holland, Sir Alfred Chatterton, and himself spent in a certain small room in Simla occupied in figures and occasionally in warm discussions over questions of policy and drafting, would always remain in his mind and probably in the minds of the others. It was a relief occasionally to have the discussions temporarily in abeyance owing to the resounding hail on the tin roof.

What Sir Alfred Chatterton had been saying about Mysore filled him with admiration and also with a good deal of regret. As he had said, the proposals of the Industrial Commission had been so largely rendered ineffective by the Reforms scheme that it was, he thought, fair to say that there was no definite policy before either the Central or the Provincial Governments at the present moment. There was a lack either of a policy or of driving power to carry it out, or of the mechanism through which that driving power must work. It was a source of great regret to him personally, and, he had no doubt, to many other people who had had much more to do with the matter than he had, that they had to turn over to the new democratic régime such an uncommonly poor showing in the matter of an industrial policy. Their predecessors had laid successfully the foundations of an agricultural policy which would continue to be followed, he believed, with increasing success. As Sir Alfred Chatterton had been saying, in India agriculture must come first, and he might just mention one fact from the Industrial Commission's report which would show how much remained to be done and what great advantages would come from an agricultural policy in the widest sense. Before the war, according to a very interesting paper by Middleton, of the English Ministry of Agriculture, the average British worker employed on land dealt with, speaking from memory, some 17 acres. Inquiries made by the Industrial Commission showed that the individual employed on land in India dealt with about 2½ acres. When one took into account the difference in yield of an acre in India and an acre in England, it would be evident that the average British worker on the land produced just about thirty times as much as the average worker on the land in India. The paper in question went on to compare the output of the English worker with that of the German worker on the land, much to the disadvantage of the former, so it could be imagined what sort of showing the Indian worker on the land would make compared with the German worker.

But from a national point of view a proper industrial equipment was a prime requirement for national self-respect and national self-development. It was the lack of this that made him regret so much that the Indian Government had failed to develop the policy and put it into effect before the coming of the Reforms scheme. Some day, when attention was turned aside from the spinning-wheel and the ballot box, to the lathe and the foundry, India might perhaps try to work out her own industrial salvation, and he was sure she would demand from those of them who were in India before an account of their stewardship, which he was afraid they must admit had been an unprofitable one.

There was not much left now that the Central Government could do in the way of encouraging industries. The principal lines it could follow were, of course, tariffs and subsidies, about which he had nothing to say, and the development of banking. As the Chairman had just remarked, this was a factor of enormous importance in the development of the industrial organisation of India. The first step taken towards banking was by Sir William Meyer when he was Finance Member. As the Government was very hard up for rupees at that time, Sir William Meyer got the local banks to induce the ryots in Eastern Bengal and elsewhere to accept notes instead of silver. That was the first step to popularising banking amongst the ignorant and suspicious peasantry. The extension of branches by the Imperial Bank of India was in the same direction, and that, he thought, also owed its origin to Sir William Meyer. With the development of banks, capital would be rendered fluid, confidence would be created in joint stock concerns, and the sense of economic solidarity in the country would be increased.

He could have wished that Sir Alfred Chatterton had not stuck quite so closely to his brief, and had told them whether the Mysore Bank had had any effects in that direction, whether it had tried to popularise banking among the better-to-do villagers or had stuck to ordinary commercial transactions. Another great problem in Indian industries which arose indirectly out of something in Sir Alfred Chatterton's paper was the question of the efficiency of factory labour. He would like to know whether factory labour in Mysore among relatively pleasant surroundings was more permanent than in the great industrial centres in India. It was very necessary that factory labour should become more permanent, and that could only come about by better surroundings and a more comfortable life for the factory hand, both inside and outside the factory.

COMMISSIONER F. ST. G. BOOTH-TUCKER (The Salvation Army) said that it had been a great pleasure to him on that occasion to hear two old friends of his Indian days, and he thought the account which Sir Alfred Chatterton had given of what had been done was simply marvellous. He remembered Sir Alfred Chatterton as a man possessed of an immense store of energy; things simply had to go when he took them in hand, and he did not know anyone else who had accomplished so much for the good of India. No reference had been made to the village banks. The speaker did not know whether these were properly included in the banking system, but he thought the village co-operative banks were a great success the last he knew of them, and they filled a great need. He found very little difficulty in getting the villagers to take part in them. The Salvation Army had a few little village banks of its own, but the first great need was for a central bank to lend to the village banks. One great advantage in India with banking was that the debtor was so absolutely honest that he not only paid his own debts but his father's and his brother's and sister's debts, and all his relation's debts. Just as an illustration, he might mention that there was a small village community, very poor—for the Salavation Army did not deal with villagers who were well off, but with the very poorest, what might be called the riff-raff, who had no capital—who came to them saying that they desired to purchase a field which was offered for 500 rupees, and that if the money were lent to them they would repay it in two harvests. The money was lent and in two harvests it was repaid. Then they said that they wanted to build new houses, for which they desired a loan of 700 rupees, and this they would repay also in two harvests. And they did repay it in two harvests. In another instance a colony of two thousand people was settled in North India. The Government would not give them land, but the Government would give the Salvation Army land to sell to them. The people who were placed on the land were carefully selected, and that colony had been established for twelve years. There had not been a single default. Everybody had paid up absolutely to time, and indeed they were one year ahead with their payments. The Salvation Army said to the people: "The Government will sell us—they will not give us any land, but they will sell us 2,000 acres; come and look at it." They went and looked at it with the eye of the farmer, and they said: "It will not do at all. It is not good enough." It was pointed out to them that the land was fairly cheap—150 rupees an acre—but they said that they would rather pay 500 rupees and have good land. Ultimately, some other land—good land—was secured at 240 rupees an acre. Thirty years were given for the people to pay, and there were no defaulters. The Government benefited, because the value of the land all-round came to be 500 or 600 rupees an acre.

The speaker went on to say that he felt there were two faults in administration. British administration in India was the most admirable in the world, but there were two serious faults. One was the system of education. With a 90 per cent. agricultural population the people were not given the education most fitted for their probable pursuit. When the children in schools were asked what they were going to do on leaving school, hands were held up, and the general answer was "Government service." This defect should certainly be remedied. A technical system of education was badly needed. Then there was one other suggestion he would make. Ninety per cent. of the population were villagers. Not sufficient attention was paid to them. He would like to see an association formed, with Her Majesty the Queen Empress at the head of it, for the special benefit of the 290 million villagers, to see that the villagers were supplied with agricultural information and implements; to encourage every kind of social well-being; to organise the distribution of reading matter and so forth; also means for cottage industries. He thought that India was superlatively suited for the silk industry, and the same cultivation might be done in India as was done in French Indo-China. In these two respects—the care of the villager and the stimulation of cottage industries—much might still be done. The villager should be made to feel that he was part and parcel of the British Empire. It would be a very great thing if Her Majesty were the head of this movement, the Vicereine, her lieutenant in India, and the wives of all the officials and of the Maharajas being members. It would not be necessary to raise a shilling outside India. The country districts were not poverty-stricken. Nearly very village had its "malaba" or charity fund. And in every district there were rich Indians, who would like to feel that their gifts were for the benefit of their own district. The Indian would feel that money was being spent in his own local interest and on things which would prove, in the long run, very valuable. Quite wonderful results might come about for India along these lines.

Mr. A. Yusuf Ali, C.B.E., I.C.S. retd., said that quite recently he was asked by a publicist in India what was the most urgent question to raise in the Assembly. He replied privately—what he had since written in public—that amongst the most urgent questions requiring the attention of the members of the Legislative Assembly were the industrial questions, and that the most useful material for the discussion of industrial questions was contained in the report of the Industrial Commission over which Sir Thomas Holland presided. Sir Thomas Holland, Sir Alfred Chatterton, and Sir Ernest Low were all three members of the Industrial Commission, and they, naturally, did not care to speak of it in the same terms in which he, an outsider, could frankly speak. In his opinion the report of the Industrial Commission ought to be studied, re-studied and acted upon. It was a matter of extreme regret that, after so much energy had been expended on it by men of great brain power, practical experience and administrative ability, so little had been done to carry out its proposals. He thought an earnest student of every aspect of the Indian problem would derive the greatest benefit and inspiration from the work of that Commission. The Report not only discussed the great problems of Indian industries, but put them in the right perspective, because the greatest industry of all was agriculture. It was not only true that ultimately every industry must depend on agriculture, but no industrial advance was possible unless it was linked up with a more efficient system of agriculture than was found in India at the present day. The two things dovetailed into each other. It was impossible to make any sustained progress in industry unless the great agricultural industry was tackled with the latest resources of science and in the light of the universal principles of economics, of which he put in the forefront the principle of avoiding all waste. It had already been pointed out that there was a great deal of waste in Indian agriculture. There was also a great deal of lack of organisation, and because of that many industrial schemes failed. The only way in which the industrial problem could be tackled was by industrialising agriculture. Good agricultural machinery was required; the villager should be helped to an understanding of bigger questions so that he should be made to feel that he was something more than a villager. For that purpose he must use quite simple agricultural machinery, and understand how one village was linked with another, and how the villages together were linked with something more central; just as happened in the case of co-operative banks. No co-operative rural bank was successful unless it had the help of the central banks, and even the latter suffered very much in their operations because there was not a great properly-managed land bank or industrial bank in India. The Tata scheme for an industrial bank had almost been a failure, not because an industrial bank was not required, but because the organisation necessary to link up the ultimate unit, namely, the village and the villager, had not been created. He would, therefore, very strongly emphasise the point that agriculture and industries must go side by side and develop on parallel lines, and that any very ambitious schemes of industrial development were foredoomed to failure unless they included the industrialisation of agriculture. Another question dealt with in the Report of the Industrial Commission related to education. He would not go quite so far as to condemn modern Indian education altogether, but, as was pointed out in the Report, the vitalising factor in education in India, namely, education of the artisan, was wanting. The most skilled scientists might be imported to perform research work, but all that work at the top, combined with all the work in village schools, would lead to a complete stultification of Indian arts and industries unless an educated working man was produced. For instance, taking the cotton industry in Bombay, there was an absence of foremen, who should be in touch with the lowest ranks of labour on the one side and the highest ranks of industrial India on the other. No doubt the great problem of education in India was to create that central link of secondary education. The third point he wished to put forward was the use of power. As the author had stated, Mysore was in the happy position of having a very fine hydro-electric scheme sufficiently big for present needs. If there was no coal in that State that was a condition that applied also to a large part of India. If the hydro-electric power in Mysore could be extended and utilised for cottage and village industries, not only would the industrial question in India be solved, but also the very much wider question of how to make the industrial life consistent with the greater ideas that now existed of clean and healthy village and rural life. In that respect Mysore had a tremendous advantage. When he visited Mysore he was struck with the cheapness of the electric current. He thought Mysore was the only town in India in which almost the poorest people had electricity in their houses; and if Mysore continued to produce electric power at the same cheap rate he looked forward to a time when the whole of the Mysore State would be dotted over with scattered cottage industries which would help to build up a proper industrial system in the State. During the time he was Member of Council for the Industrial Department in Hyderabad, he felt that ambitious schemes requiring large expenditure of capital, in the conditions which existed of want of economic confidence, were a little premature; but that the stimulus given to all small industries by means of improved looms, or improved electric hand mills for the grinding of corn, or any machinery which would help to increase to produce and yet not take people too far away from their villages, would be a great boon and actually practicable in the present state of India. Those were the directions in which not only Mysore but every Province of the whole of India ought to be moving; and if self-government in India was to be a reality instead of merely a matter of paper and wordy warfare, it could only come by building up a sound economic system in every part, so that all classes of the people could help in building up the new India—the self-supporting India and the happy and contented India.

MR. W. G. WHIFFEN thought there could be no doubt that the cause of unrest in India was largely due to the lack of occupation requiring intelligence. The author had indicated many sources of wealth which should be exploited and had shown how the work was hampered by want of capital, by mismanagement and by lack of co-operation. Co-operation was essential, not only in banking circles but among the people of the villages. The author had pointed out the great need for industrial enterprise which would give employment to the people. He had been deeply impressed by the history the author had given of the Mysore State and its development during the last 50 and more years, especially the last 25 years. The development of the railway service, the roads and the magnificent hydro-electric power station were great achievements. The price at which electricity was produced and distributed in Mysore and Bangalore was extraordinarily low compared with prices ruling in London. The plant worked by the head of water above the Cauvery Dam must be an extraordinarily fine producing plant from the point of view of electricity. It was almost common knowledge that a good part of the gold mines in Kolar could not be worked unless they had the advantage of cheap electricity supply and cheap power. The textile industries would certainly grow in Mysore for very much the same reason, namely, because cheap power and cheap water were available. The subject on which he was more qualified to speak than any other was that of the work of the Indian Institute of Science which had been established in Bangalore. In 1915 he was visited by Dr. Sudborough, representing that Institute, who put before him the desirability of several developments, more especially in regard to the development of the industry of the manufacture of essential oils in India. Dr. Sudborough made his case so clear that, as a distiller of essential oils, and his firm having been distillers for the last three or four generations, he (Mr. Whiffen) saw at once there was an enormous advantage in the proposition for distilling the wood in Mysore, exporting the oil, instead of sending the heavy wood to England, Europe and America. As there were only about six lbs. of oil in 100 lbs. of wood the saving in transport was self-evident. At that time he did not know what was the driving force behind that young industry, as he had not had the pleasure of meeting the author. By August, 1916, a year after he met Dr. Sudborough, oil of excellent quality was being produced and sent to London. That was done in times of war, when the transit problem was a very difficult one and freights were hard to obtain. It was, therefore, an extraordinary achievement that a factory should have been erected and equipped and oil distilled and put on the European market within 16 or 18 months of its inception. In 1916, in addition to the sales of oil that were made in India, over two tons of oil were sold in this country; while in 1917 the figure had risen to 13 tons, in 1918 to 23 tons, and in 1919 to 63 tons of distilled oil. When it was borne in mind that the value of the oil ranged from 35/- to 50/- per lb., it was evident that it represented a very important industry. He was aware that there was a good deal of difficulty with regard to labour in India, but as compared with English labour it cost much less and there was no doubt that alone represented a great advantage. There had been a tendency during the last two years for European and other countries to put up tariffs against manufactured articles; but if care was exercised there was no reason why the sandal-wood oil industry should not be sufficiently strong to stand on its own merits, and not be much interfered with by an increase of import tariffs. London was practically a free port for such goods as could not be manufactured in the country, and for that reason it was an excellent centre for the distribution of essential oils and many other products that Mysore might be able to send to this country. All intelligent people in England hoped that the happiness of the people of India might be increased; and to that end he had no hesitation in stating that happy employment in their villages and their towns, under suitable conditions was about the best thing that could be done for them.

DR. ARTHUR HAYDON said that after perusing the paper he had come to the conclusion that too much time was spent in educating Indians to become members of the Government Service. He would like to know who controlled the educational policy of Mysore—whether it was controlled centrally or locally. At one time the policy was adopted in China that the people were trained in all sorts of old Chinese poetry; but that system was given up many years ago. The Chinese were now trained on very broad lines, and the general policy was that all Chinese who intended to enter Government Service must travel in foreign countries. It seemed to him that if a new policy were adopted with regard to the education of the natives of India it might be a great advantage.

SIR ALFRED CHATTERTON, in reply, after thanking the various speakers for the kind way in which they had referred to his work in Mysore and other parts of India, said that Sir Ernest Low asked for particulars in regard to the conditions of labour in Mysore. Most of the labour employed in the mills of Mysore was imported from less favoured parts of India, and when the people got to Bangalore and Mysore they generally stayed there. Sufficient care was not always taken, however, in the selection of the sites of the factories. The site selected for one of the cotton mills recently erected in the neighbourhood of Mysore was malarious, and as a consequence much trouble was experienced, due to the fact that the coolies did not work regularly. He was sure all present were glad that Commissioner Booth Tucker had attended the meeting, and that he was still taking an interest, as he had done for so many years, in matters connected with India, especially in the development of the silk industry in Mysore, which he had attempted to foster through the agency of the silk farm near Bangalore, originally started by the late Mr. J. N. Tata and handed over many years ago to the Salvation Army. The chief difficulty to be faced in extending silk cultivation in Mysore was to get sufficient food for the worms.

There were already 30,000 to 40,000 acres under mulberries. In Mysore the mulberry was a shrub which needed irrigation to produce a succession of crops of leaves to feed poly-voltine worms. The ultimate yield of silk was roughly proportional to the quantity of food supplied to the worms, and whether the silk culture should be on a mono or a poly-voltine basis was determined by the number of flushes of leaves which could be obtained in a year. In Mysore the extension of the silk industry was simply a question of substituting mulberries in place of food crops, and that ultimately was decided by economic considerations.

Mr. Yusuf Ali had referred to the Tata Industrial Bank, and had ascribed its limited success to the fact that no organisation had been created to link it up with the village and the villager. As a matter of fact, the Bank had been started to finance the industries of India, and not to compete with or assist the Co-operative Credit Open Banks, and its lack of success was due to the discovery that ample facilities for the financing of sound industrial undertakings already existed in India. The cry for industrial banks in India came from people who were inadequately equipped to carry on industries, and who were in consequence refused financial assistance by the existing banks and by the houses of agency. It had been his duty to examine many such applications, and almost invariably he had to recommend that they should be rejected, either because the projects were unsound or the promoters were lacking the necessary experience to carry them out. They had seldom any security to offer and their schemes were hopeless propositions from a business point of view.

Dr. Haydon had asked for information as to who controlled the educational policy of the State. Ultimately it was the Maharaja, but the Government was normally carried on by the Dewan and two or three Councillors. Lately the Legislative Assembly had been developed to bring it more or less into line with similar legislative bodies in British India. The educational policy dated back to the days of the Commission, and was practically the same as that of the Madras Presidency since the Mysore Colleges were affiliated to the Madras University. As stated in the paper, a few years ago Mysore established its own University, and a unique opportunity had then presented itself to establish a better system of education, but the Government had not availed themselves of it. The position, however, was improved to this extent, that they were now free to do what they liked, and at any time they could introduce reforms if such were considered desirable. Personally he thought that the expenditure on education in Mysore was utterly disproportionate to the expenditure on industrial development, and that the State would be faced in a very aggravated degree at no very distant date with the problems arising from an unemployed and discontented *literati*.

On the motion of the Chairman, a vote of thanks was unanimously accorded to Sir Alfred Chatterton for his paper.

OBITUARY.

Sir Steuart Colvin Bayley, G.C.S.I., C.I.E.—Among the many prominent Fellows whose loss the Royal Society of Arts has recently deplored, few will be more sincerely regretted by those who knew him, whether as a colleague or as a personal friend, than Sir Steuart Colvin Bayley, who died in London on the 5th June, at the ripe age of 88 years. He came of a Manchester family, which has long been connected with India, being the youngest son of William Butterworth Bayley, who landed in Calcutta in 1799, and had a distinguished career in the Honourable East India Company's Civil Service, in the course of which, being then the senior member of the Governor-General's Council, he officiated as Governor-General from March to July, 1828, and held office as a Director of the Company until the assumption by the Crown of the direct government of India.

Steuart Bayley, who was educated at Eton and Haileybury, entered the Bengal Civil Service the year before the Mutiny. He was posted to Bengal, where he was selected in 1873, at an exceptionally early age, for the important office of Commissioner of the Patna Division. In this capacity, during the Lieutenant-Governorship of Sir Richard Temple, he had to cope with the Bihar famine, his successful handling of which was recognised by the conferment on him of the C.S.I. and led shortly afterwards to his appointment as Personal Assistant to Lord Lytton, when this distinguished Viceroy proceeded to Southern India during the famine which devastated the Madras Presidency in 1877-8. In May, 1878, he received the K.C.S.I., and in June was appointed to the Chief Commissionership of Assam. This province he administered for three years, during six months of which he officiated, in addition to his own duties, as Lieutenant-Governor of Bengal owing to the deputation in 1879 of Sir Ashley Eden as President of the Army Commission. In 1881 he was transferred to Hyderabad as Resident at the Court of His Highness the Nizam, and in the following year was appointed Home Member of the Governor-General's Council. During his tenure of this office it fell to his lot to take a large share in dealing with the anxious and troublesome situation created by the introduction and subsequent passage in a modified form of the Ilbert Bill. In April, 1907, he was selected by Lord Dufferin to succeed Sir Rivers Thompson as Lieutenant-Governor of Bengal. In the words of the writer of the obituary notice which appeared in the *Times* of the 6th June, "Bayley kept a careful eye on the progress and development of the great province, which he furthered on the lines adopted by his eminent predecessor, Sir Ashley Eden. He did much to calm the racial feeling which had been aroused by the policy of Lord Ripon, more particularly by the Ilbert Bill. Bayley was well suited to the *role* of conciliator, for he combined breadth of view and progressive sympathies with a characteristic which Kaye, the historian, attributes to his father—'his unfailing kindness of heart and suavity of manner endeared him to all who had the privilege of coming within the reach of their genial influence.' Sir Steuart was well described by his intimate friend, Sir George Birdwood, as 'this truly kingly man'."

In 1890 he left India for good, having been appointed Political Secretary to the Secretary of State for India, and five years later he became a Member of the Council of India, which office he held for the full period of ten years. He was promoted to the G.C.S.I. in 1911.

Sir Steuart Colvin Bayley joined the Society in 1891. In that year he made his first appearance here, presiding at a meeting when a paper on "Indian Village Communities" was read by Mr. B. H. Baden-Powell. Thenceforward he was a very regular attendant at meetings of the Society, taking the chair on many occasions, and very frequently speaking in the discussions. In 1895 he was elected a member of the Council, and he continued to serve on it, with the brief necessary intervals, until 1921, when he resigned on the ground of age. In 1911 he was nominated by H.R.H. the President a Vice-President of the Society, in recognition of the services which he had rendered to it. He was Chairman of the Indian Section Committee from 1896 to 1903, and from 1906-8 he was Chairman of the Council. In this capacity he delivered two addresses: the first was devoted mainly to the work of the Indian Section, with some interesting suggestions as to the possible lines on which it might be developed; the second, entitled "Lord Clive and his

Part in the Foundation of the Indian Empire," was a brilliant account of possibly the most stirring and romantic period in the history of the British Empire. Clive, as Sir Steuart mentioned, was a member of the Society, and was one of the few Commoners (William Pitt being another) who undertook to contribute an annual subscription of five guineas. The first wife of Sir Steuart's great grandfather was a sister of Clive's mother, and for seven or eight years, from the age of three, the lad was entirely brought up by this ancestor. It is from letters of his that most of the glimpses we have of Clive's early boyhood are derived. The date on which Sir Steuart's address was delivered (1907) was particularly appropriate, because it was the 150th anniversary of the Battle of Plassey.

Sir Steuart took a very warm interest in the work of the Society. He seldom missed a meeting of the Council, where his great experience, ripe wisdom, and lovable nature won him the respect and affection of his colleagues. Of him it may truly be said that he lived up to the motto of his family, *Quicquid agas age pro viribus.*

NOTES ON BOOKS.

NEW REDUCTION METHODS IN VOLUMETRIC ANALYSIS. By Edmund Knecht, Ph.D., M.Sc.Tech., F.I.C., and Eva Hibbert, M.Sc.Tech. Second Edition. London: Longmans, Green and Co. 8s. 6d. net.

Despite the rather wider implication of its title, this valuable monograph is essentially a study of the potentialities of titanous chloride as a quantitative reducing agent. On this subject the authors, especially Dr. Knecht, have published numerous investigations in the last twenty years, and it may be taken that they have established beyond all doubt the value of the method for many purposes. The question of expense would probably need consideration, though the authors consider that the price of the 20% solution now obtainable renders it available for commercial or scientific work.

It could not be expected that a reducing agent, sufficiently powerful to carry out the great number of reactions here described, would be stable in the presence of air, and so we find that the burette must be supplied from a stock-bottle in which an atmosphere of hydrogen is maintained. The resulting complication, however, is not very much greater than that encountered in baryta titrations.

More than one indicator is available, in addition to the electrometric method, which will presumably grow in popularity as more workers become accustomed to the technique, though the present authors merely refer to the paper in which its application is described.

The number of useful reactions is large. Seven of the common metals can be estimated, in addition to tungsten, molybdenum and vanadium; also a number of salts and other inorganic substances of an oxidising nature, while of course other reducing agents can in many cases be determined by back-titration. The organic estimations also are very important; the substances including nitro-, nitroso-, and diazo-compounds, osazones, sugars (by several indirect methods), and quinones, in addition to numerous dye-stuffs.

In the present edition the subject-matter has been to a considerable extent re-arranged, though, several inconveniences are still presented. After the general character of each estimation has been discussed in turn, the whole series is recommenced, the exact analytical procedure being now set forth. The result is that the information relating to any particular estimation has always to be sought in two different sections of the book. Errata seem to have been not quite completely eliminated; *vide* p. 15, where the quantitative result of the methylene blue estimation of potassium bichromate is given twice over in rather baffling fashion. All workers who make use of the book will be grateful for the bibliography.

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FRIDAY, JULY 3, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICE.

VISIT TO CROYDON AERODROME.

At the invitation of the Air Ministry two parties of Fellows of the Society visited the Croydon Aerodrome on the afternoons of Thursday, June 25th, and Friday, June 26th. Arrangements for showing the Fellows over the various parts of special interest were made by Lieut.-Colonel F. C. Shelmerdine and subsequently the visitors were entertained at tea.

PROCEEDINGS OF THE SOCIETY.

ANNUAL GENERAL MEETING.

The One Hundred and Seventy-first Annual General Meeting for the purpose of receiving the Report of the Council, and the Treasurers' Statement of Receipts and Payments during the past year, and also for the Election of Officers and New Fellows, was held in accordance with the By-Laws on Wednesday, June 24th, at 4 p.m. Sir CHARLES S. BAYLEY, G.C.I.E., K.C.S.I., in the Chair.

THE SECRETARY read the notice convening the meeting, and the Minutes of the last Annual General Meeting, held on June 25th, 1924.

The following candidates were proposed, balloted for, and duly elected Fellows of the Society:—

Bhajiwalla, Hormusji Jehangirji, Bombay, India.
Bhajiwalla, Edy Jehangirji, Bombay, India.
Binns, Herbert, Keighley, Yorks.
Brinton, Selwyn, M.A., Southwick, Sussex.
Burnham, The Right Hon. Viscount, C. H., London.
Camp, Lee G., M.Am.Soc.M.E., Havana, Cuba.
Castellani, Aldo, C.M.G., M.D., F.R.C.P., London.
Cruickshank, William Shaw, Shanghai, China.
Dale, Fredrick Hallard, Bhopal, Central India.

Dalton, John, Harrow Weald, Middlesex.
Dave, S. S., Raigarh, India.
de la Macorra, José, Junr., Mexico City.
Dock, Herman, Guadalajara, Mexico.
Gresswell, Ronald Kay, Southport, Lancs.
Guthrie, David Leslie, London.
Hartman, Dr. H., New York City, U.S.A.
Herr, Miss Helena, M.B.E., Chislehurst, Kent.
Kennedy, A. M, Montgomery, Alabama, U.S.A.
Kirby, John F. Campbell, Assoc.M.Inst.C.E., Kutch, Bombay, India
Lane, Eric William, King's Langley, Herts.
Langler, Alfred, Perth, Western Australia.
Mistry, Munchershaw Pherozshaw, Bombay, India.
Mitchell, Lieut.-Colonel Archibald Maclaine, D.S.O., Edinburgh.
Morse, Mrs. Virgil D., Ithaca, New York, U.S.A.
Mosely, Miss Kathleen, London.
Noble, William Arthur, F.C.S., West Hartlepool.
Nordin, John A., Finspong, Sweden.
Oppermann, Fred M., Holisov u Stoda, Czecho-Slovakia.
Overbeck, Otto, F.C.S., Grimsby.
Pitman, Isaac James, Bath.
Rajagopalan, T. R., Madras, India.
Rice, Sidney A. S., London.
Sachdev, Dr. Ganesh Das, London.
Saini, Ralla Ram, Jammu, Kashmir, India.
Seymour-Hall, Charles Cyril William, London.
Shaw, Arthur H., M.I.E.E., M.I.Mech.E., Ilford, Essex.
Stanton, Albert Lennox, Bombay, India.
Thornton, Numer, Thornaby-on-Tees.
Timson, Ernest Arthur, Kettering, Northants.
Upasena, Esapala, London.

The Chairman appointed Mr. R. à-Ababrelton and Mr. Byron Brenan, C.M.G., scrutineers and declared the ballot open.

The Secretary then read the following

REPORT OF COUNCIL.

I.—Ordinary Meetings.

Since the last Annual Report was published Senatore Marconi has delivered two addresses before the Society. On July 2nd, 1924, he read a paper entitled " Results obtained over very long Distances by Short Wave Directional Wireless Telegraphy, work generally referred to as the Beam System." As long ago as 1899 Senatore Marconi showed that it was possible, by means of short waves and reflectors, to project the rays in a beam in one direction only. About 1916 he came to the conclusion that we had got into a rut by confining researches to long waves, and he decided to return to the investigation of short wave telegraphy. The paper summarised the results of this work, which were so successful that on May 30th, 1924, intelligible speech was transmitted for the first time in history from England to Australia. The advantages of the beam system are various: the capital cost of the stations is greatly lowered, and a much smaller amount of power is required, so that it should be possible to make a substantial reduction in telegraphic rates; as only stations within a certain angle of the beam can receive messages, a comparative privacy of communication is secured, which may be of the greatest value in time of war, and the rate of transmission is far greater than with the high-power long-wave system.

Owing to absence abroad Senatore Marconi, who had been elected Chairman of the Council, was unable to deliver the inaugural address at the opening of the Session. A special meeting was, however, held on December 11th, when the Chairman spoke on "Radio Communications." Since reading his paper in July, Senatore Marconi had been continuously engaged in further prosecuting the investigations then described, and he told of the progress that had been made right up to the night preceding the delivery of his address. During these five months very considerable advances had been made, and the results seemed amply to justify the opinion that Beam Stations employing a comparatively small amount of power and much lower and smaller masts would soon be able to communicate at practically any hour of the day or night with any part of the Empire.

As long ago as 1863, Colonel R. E. Crompton built a steam-driven motor car and had it running on the road. He was, therefore, probably better qualified than anyone else to read a paper on "The Motor Car: its Birth, its Present, and its Future." He was disposed to assign a very great deal of the credit for the development of the motor car to R. W. Thomson, of Edinburgh, who was mainly instrumental in suggesting the use of rubber tyres. Colonel Crompton worked for some time in very close co-operation with Thomson, and realised to what an extent the early improvements of the car were due to this pioneer. He had a great many interesting things to tell of his first experiences with motor cars both in England and in India, in which latter country he did good service to the Indian Army by his early experiments in mechanical transport.

Mr. Llewelyn B. Atkinson has for many years made a careful study of the various problems connected with artificial incubation, and the results of his observations were given in his full and exhaustive paper, "The Scientific Principles of Artificial Incubation." The main lesson which he had learnt was to copy the hen as closely as possible, and he had found that his hatches came off most successfully when actual contact was applied to the upper surface of the egg in the same way as a hen transmits heat to it. This was achieved by placing a very thin sheet of india-rubber upon the top of the eggs. There seems to be no doubt that healthy variety of temperature increases the metabolism in the embryo chick in the egg, and optimum results were obtained when the upper surface of the egg was kept at a distinctly higher temperature than the lower surface.

It has been customary, in teaching science, to divide it up into watertight compartments—e.g., Chemistry, Botany, Geology, and Physics (which again is subdivided into heat, light, sound, magnetism, electricity, etc.). The tendency of this practice is to make the sciences seem, especially to young pupils, dry, academic and remote from the world about us. Professor C. A. Carus-Wilson, in his paper, "The Teaching of Science in Secondary Schools," pleaded that a central theme should be taken round which all the branches of science might be grouped, and he suggested that this subject should be called "The Properties and Uses of Materials." He suggested that the science teacher should begin by explaining the nature of objects in common use; e.g., he might examine various kinds of wood, and make experiments to demonstrate their properties, density, elasticity, toughness and strength. Sections with and across the grain should be shown, to illustrate the manner in which trees grow. Similarly other substances should be examined, such as rubber, cork, ivory, amber, leather, etc., and when solids have been dealt with, liquids and gases might be similarly treated.

Mr. C. F. Elwell gave a remarkably interesting display of "Talking Motion Pictures." By the aid of Dr. Lee de Forest's three-electrode valve it has been made possible to photograph sounds synchronously with the persons emitting them. Sound waves are transformed into electric currents, electric currents into light, and this is recorded on the sensitised celluloid film. The problem of securing perfect synchronisation has thus been solved. It was generally agreed that at present the weak link in the chain is the loud speaker, which certainly is not very successful in transmitting certain sounds; but when this part has been improved, it seems impossible to doubt that there will be a very big future for talking films.

Colombia, a country of some 450,000 square miles, with sea ports on both the Atlantic and the Pacific Oceans, is a region of immense potential wealth. Mr. Norman Thomson, in his paper, "Colombia as a Field for Development," outlined these possibilities. Among her principal crops are coffee, cacao, coconut, cotton, tobacco, bananas and maize, while some ten million head of cattle thrive on the pastoral districts. The mineral wealth is also great, and includes gold, silver, platinum and coal. All that is wanted to develop these resources is capital and means of transport. British capital and British engineers have during the past hundred years done much to assist in establishing the prosperity which Colombia now enjoys—at present her money is at par with the currency of the United States of America—and Mr. Thomson is of opinion that Colombia still offers a vast and lucrative field for British capital and enterprise.

Mrs. Graydon-Stannus, in her paper "Irish Glass, Old and New," gave an extremely interesting account of the growth of the industry in Ireland. By the end of the 16th century there was undoubtedly a factory, or "Glass House," in County Cork, and by about 1630 glass was being made on a large scale in Dublin, where the manufacture continued right up to 1896. Other centres were Belfast, Drumrea, Newry and, most famous of all, Waterford. The characteristics of the various kinds of glass were described by Mrs. Graydon-Stannus, and illustrated by some beautiful specimens from her own collection. In the second part of the paper she described the glass which she is herself making in London, mainly from old Irish recipes. This glass, of which a large selection was on view, is very distinctive in character, and as none of the articles are standardised, there is a very pleasing variety and individuality about them.

The London County Hall occupies a site of about six-and-a-half acres, and contains nine storeys. The task of providing electrical equipment for a building of this size is very considerable. It was entrusted to Mr. Charles A. Baker, Assistant Engineer of the London County Council, who described the details of the work in his paper " The Electrical Equipment of the London County Hall." In the sub-basement is accommodation for a 10,000 volt station, in which three simple phase transformers, each of 250 kilowatts capacity, are located. Electrical energy is purchased from the London Electric Supply Corporation, Ltd., and the Westminster Electric Supply Corporation, Ltd., and is furnished by two generating stations, one at Deptford, and the other at St. John's Wood. There are over 6,000 lamps in the building, and, besides these, a great deal of current is required for the operation of lifts, ventilating fans, boiler pumps, refrigerating plant, clocks, etc. Not the least interesting feature of the equipment is the automatic telephone exchange. At present there are some 640 extensions on this system, and the average number of calls is about three thousand a day.

In the course of an exhaustive paper on " The Diesel Engine in Navigation," Sir James Fortescue-Flannery described the general principles of the Diesel engine, and in greater detail the main features of the most important four-cycle and two-cycle engines. Rapid advances are being made in the number of Diesel-propelled sea-going vessels, the figure having risen from 297 in 1914 to 1,950 in 1924; of ships now under construction, nearly a million tons are being built for propulsion by internal combustion engines, whilst slightly over a million and a half tons are being built for propulsion by steam.

The Trueman Wood Lecture was delivered by Sir Ernest Rutherford, who chose for his subject " The Stability of the Atom." The discovery of the electron was due to Sir J. J. Thomson, but such knowledge as we possess regarding the nucleus of the atom is almost entirely due to the work of Sir Ernest Rutherford. In the course of a brilliant lecture he described first the changes that are believed to take place in the outer atom during the absorption or emission of energy, and secondly how far these ideas can be applied to explain the structure and modes of vibration of the atomic nucleus. This nucleus is a world of its own, of whose structure at present very little is known; but a number of modes of attack are open to us, and it is hoped that by their means our knowledge of the subject may be largely increased in the near future.

In his paper "Modern Atmospheric Conditions, with special reference to London," Dr. J. S. Owens gave an exhaustive analysis of the London atmosphere and the causes of fog. Public attention has frequently been drawn in recent years to the amount of damage done to buildings by the impurity of our atmosphere. Sir Frank Baines, for instance, in the course of the discussion that followed the paper, stated that in one of our great public buildings in fourteen years the surface of the Portland stone had gone back over one-eighth of an inch. With decay proceeding in this manner all over the Metropolis, it is easy to imagine what an enormous amount of damage is being done year by year to our buildings, and more especially to those of ancient and historic interest. The damage to human life and health is certainly not less important, while certain exhibits from Kew Gardens showed the disastrous effects of impure atmosphere upon vegetation. Dr. Owens did not on this occasion deal with the remedies for smoke prevention. These, he said, are already well known; what is now wanted is to bring people up to the point of determining to make use of these remedies.

Sir Dugald Clerk, to whom the Society is indebted for numerous papers and lectures, in addition to many other invaluable services, read a paper on "The Power of Internal Combustion Engines for Motor Cars." The present rating of motor cars for the purposes of taxation is based on the well known Royal Automobile Club formula, proposed in 1906 by Sir Dugald. At that time, owing to the difficulty of obtaining standard mean pressures, standard cylinder proportions and piston speeds, he expressed the opinion that the accuracy of 1906 would be inaccuracy in 1911 and positive error in 1916, and the event has justified his prophecy. To diminish the injustices which have arisen in the incidence of taxation, Sir Dugald Clerk supported the suggestion of Mr. L. H. Pomeroy, who advocates that "in the existing state of design the fundamental dimension of a maximum horse-power equation should be the area of the inlet valve," and he was of opinion that by some such method it would be possible to get a much closer approximation to the power of an engine than with any cylinder dimension rule.

M. Emile Cammaerts in his paper, "The Reconstruction of Belgian Towns," described the notable achievement of his fellow-countrymen in repairing the havoc wrought by the war. Out of 100,000 houses destroyed, 95,000 have been rebuilt, and if the 12,000 temporary buildings which have been erected over the country are taken into account, the number of houses to-day is actually larger than it was before the war. In some places the labour of reconstruction was enormously increased by the ingenuity of the German engineers who had transformed towns into mazes of concrete works. In Dixmude, for instance, about 65,000 cubic feet of concrete had to be removed before the new town could be rebuilt. These results have only been accomplished by the spirited devotion of all concerned, from the Ministry in charge of the works, to the last navvy—a devotion which is evidenced by the fact that, although an eight-hour day had been adopted by the Belgian Parliament, the people insisted upon working more than eight hours.

Mr. Claude H. Friese-Greene gave a striking exhibition of films produced by the Friese-Greene process of colour cinematography, and read a paper in which he explained his method. The process is a two-colour one, and while it is not claimed that it is as successful in reproducing all shades of natural colours as some of the three-colour processes, it certainly has two great advantages over them. It is very economical, the cost of a film produced by this method being very little more than that of a black and white film, and it can be shown from an ordinary cinematograph projector. Many of those who saw the pictures exhibited by Mr. Friese-Greene were surprised to find that a two-colour process could give results so close to the colours of Nature.

Mr. William Nunn, in his position of Adviser to the Siamese Government on Customs and Excise, had unrivalled opportunities for studying the trade of that little known country, and in his paper, " Siam : its Progress and Possibilities," he summarised his experiences. Since the middle of the nineteenth century, under a despotic but benevolent monarchy, Siam has been making slow but steady progress in administration and finance, education, means of communication, agriculture and trade. The total trade amounts to £30,100,000, of which £13,600,000 represent imports and £16,500,000 exports. Of the latter, rice accounts for £13,000,000, tin for £1,700,000, and teak for £560,000. In the past twenty years the volume of trade has been more than doubled, and, though nothing in the nature of a boom is to be looked for, there is every prospect of a continuance of steady progress. In order to develop the commercial possibilities of the country, a good deal of capital is required, and as this is not to be found in Siam it must be introduced from outside sources.

Mr. Cedric Chivers, in his paper on " Bookbinding," explained that, in consequence of the deterioration in the quality of paper during recent years, the traditional methods of binding had become comparatively ineffective with modern books. With the aid of a series of micro-photographs he showed the necessity for a drastic change in the treatment of books of to-day by special means of sewing, and in some cases by impregnating the paper with a strengthening solution before attempting to bind the volume. In dealing with the question of materials for binding, he paid a very handsome tribute to the value of the Society's Report on " Leather for Bookbinding," and then proceeded to describe in some detail the qualities of Niger leather. Among many interesting exhibits were several specimens of old and worn-out bindings which were preserved and shown to great advantage under a scarcely noticeable covering of transparent vellum.

" The Modern Production of Sheet Glass " was the subject of a paper by Professor W. E. S. Turner. Great strides have been made in recent years in this industry, and plate-glass is now manufactured by continuous processes that would have been hardly conceived as possible five-and-twenty years ago. The principal of these methods, such as the Fourcault and the Libbey-Owens, were described in detail, and the lecturer concluded with an excellent account of the very latest developments which are due to the genius of Mr. Henry Ford.

Mr. Henry G. Dowling read a paper entitled "Wallpaper: its History, Production and Possibilities," which was illustrated by numerous lantern slides and some very beautiful specimens. After a brief historical survey, he described in detail the principal methods of producing wallpapers, viz., (1) hand printing from blocks; (2) machine printing; (3) stencil; and (4) hand painting. In the course of his survey he paid a great and well-deserved tribute to the work of William Morris, whose well-known "Daisy" paper established a record in the popularity of a single design. Turning to the prospects of the industry, Mr. Dowling expressed the belief that manufacturers are realising the necessity for giving a training in art as well as in the theory and practice of their craft to young men entering the decorating trade—and in this connexion it is interesting to note the scholarship which has recently been instituted by Messrs. Lewis Berger and Son, Ltd., under the Society's Scheme for the Improvement of Industrial Designs, to enable apprentices or young craftsmen in the painting trade to attend a short course of study at the Royal College of Art, London. Mr. Dowling also pleaded for the training of salesmen in the principles governing good decoration, and for practical co-operation between manufacturers and Government Schools of Art.

Dr. Andrew Balfour, in his paper, "The Trend of Modern Hygiene," urged the need for popular education in matters of public health, and drew attention to what is being done in this connexion in the United States, where the importance of the press and even of the cinematograph is much more fully recognised than in this country. With regard to our tropical possessions, he considers that we are not yet fully alive to their hygienic needs, and he pleaded for sympathetic and scientific co-operation. In India, for instance, as was pointed out in the discussion on the paper, the work of Public Health is terribly crippled by the want of funds, and, although money spent on these objects could hardly be invested more profitably, the Medical Officers of Health find that their departments are starved. Dr. Balfour spoke in praise of the Health Section of the League of Nations and of the International Health Board, which has spread its campaigns all over the world: it is fighting hookworm in many territories, mosquitoes that carry malaria and yellow fever, tuberculosis, etc.; it has aided in the medical education of the Chinese, and has given large grants to many countries for the development of teaching and research in public health.

Air Vice-Marshal Sir Sefton Brancker, whose historic flight from London to Burma and back has done much to stimulate interest in flying, read a paper on "Commercial Aviation." He described the various existing air-routes of Europe, gave details as to their methods of operation, and quoted statistics to show the comparative safety of civil aviation. It is hardly necessary to insist upon the value to the business man of the time which can be saved by means of flying. Not less valuable is the part which it plays in drawing closer together the various parts of the Empire; while the necessity which long distance routes involve of working harmoniously over different countries should do something towards ensuring peace among the nations.

Before a joint meeting of the Royal Society of Arts, the Royal Aeronautical Society, and the Anglo-Batavian Society, Mr. Thomassen à Thuessink van der Hoop read a paper on "The Flight to the Netherlands East Indies." Mr. van der Hoop started from Amsterdam in September, 1924, flying a Fokker VII. machine. The only serious delay occurred in Bulgaria, when engine trouble developed, and difficulties were experienced in effecting repairs; but when these had been overcome the flight was continued until Java was reached without further mishap. Mr. van der Hoop, who spoke in excellent English, gave an interesting account of his journey, illustrating it by numerous photographs taken from the air. Though many of the scenes were familiar to a number of the audience, the angles from which the pictures were taken were new to nearly all, and some of them, especially the photograph of the Taj Mahal, were greatly admired.

Exactly a hundred years ago the Royal Society of Arts awarded a silver medal and a premium of thirty guineas to William Sturgeon for his invention of the electromagnet. At that time Sturgeon was a private soldier in the Royal Artillery. The importance of the invention can hardly be estimated, as the electro-magnet is the basis of nearly all the technical applications of electricity. On it depend the dynamo for generating electric current, the electric motor, the telegraph, the telephone and the electric bell. It also provides one of the most important tools of the scientific investigator. Professor J. A. Fleming gave an admirable address, entitled "William Sturgeon and the Centenary of the Electromagnet," in the course of which he not only told what is known of Sturgeon and his invention, illustrating the paper with a model of the original magnet made from Sturgeon's description and drawings, but he discussed at length some of the scientific problems connected with magnetisation, and the remarkable properties of such metals as manganese steel and "permalloy."

At the last Ordinary Meeting of the Session, the Right Hon. Sir Alfred Mond gave an address on "The Unemployment Problem." He expressed surprise that Governments should be allowed to come and go without dealing with the question. To do this should be made the one test of success. After summarising in some detail the present situation in the principal industries of the country, he referred to the scheme which he had brought forward for the subsidising of employment, and which has recently been the subject of much discussion in Parliament, the press and elsewhere. While not denying that there might be difficulties in carrying out his proposals, he claimed that the scheme was at least an attempt to do something to alleviate the trouble. At the worst it could but fail, in which case we should only be as we were; whereas, if it succeeded, it would do much to re-establish the confidence of the workers in those who believed that the existing social structure was capable of dealing with the problems of their present life.

II.—INDIAN AND DOMINIONS AND COLONIES SECTIONS.

Seven Indian meetings, including the annual Sir George Birdwood Memorial Lecture, and three Dominion and Colonial meetings, were held. There was also one joint meeting of the two sections.

The Memorial Lecture was delivered by Sir David Prain, the subject being "Government Botanical Gardens." The Indian papers were: "Problems of Food with Special Reference to India," by Lieut.-Colonel R. McCarrison; "Population Problems from the Indian Census," by Mr. J. T. Marten; "The Development of Indian Universities," by Sir Henry Sharp; "Indian Meteorology," by Sir Gilbert Walker, F.R.S.; "Industrial Progress of the Mysore State," by Sir Alfred Chatterton; and "The Heart of Asia and the Roof of the World," by Brigadier-General Sir Percy Sykes.

The Dominion and Colonial papers were: "Economic Research in Tropical Development," by Mr. Walter Ranald Dunlop; "Transport in Tropical Africa," by Mr. R. H. Brackenbury; and "Some African Problems," by the Parliamentary Under Secretary of State for the Colonies, the Hon. W. Ormsby-Gore, M.P.

The remaining paper, read at the combined meeting was, "The British Empire Exhibition," by Lord Stevenson.

Sir David Prain began his learned discourse by acknowledging his indebtedness to Sir George Birdwood for help in economic inquiries in regard to their historical aspect and by urging that, while all botanic gardens depend for success on their capacity to enlist the sympathetic co-operation of cognate organisations, those of Asia owe their formation particularly to motives rather different from the reasons that have led to the existence of most institutions of the kind in Europe. Many overlook the fact that the botanic garden has been created not for the amenities it possesses as a place of public resort, but to further botanical ends, its workers indeed being subject to influences that hardly affect those privileged to labour in the field, the cabinet or the laboratory. While some five botanic gardens in Europe out of six began as "physic gardens," the connexion between "botany" and "medicine" was not, as is sometimes believed, essential but really accidental. The urgency of the need for botanical aid in which renaissance "phytology" stood was less concerned with new drugs than new foods. The garden formed by Aristotle, in which his pupil Theophrastus taught, was nearer in purpose to a modern botanic garden than a "physic garden" of the sixteenth century. In present circumstances considerable recurrent expenditure is required and attempts to produce direct revenue have to be discouraged. There is now only one Government Botanic garden in India. But the return brought by a botanic garden is indirect, and how vast the return may be South East Asia knows by what has been accomplished in the establishment of such industries as those connected with tea, cinchona and rubber. All the outlay in this respect at Calcutta, Buitenzorg, Peradeniya and Singapore, has been repaid a hundredfold, to say nothing of the almost incalculable saving to industry and commerce by the avoidance of enterprises doomed to failure. In certain European scientific circles it has been contended that the day of botanic garden exchanges of useful plants is over, but this is not the opinion of the student of genetics, nor of those interested in plant-breeding and plant-importation in the Western Hemisphere.

The problems of food to which Lieut.-Colonel McCarrison directed attention in a paper described by the Chairman of the meeting, Professor Henry E. Armstrong, F.R.S., as of "great public importance," relate to quantitative faults in the dietaries of human beings and to their connexion with disease. Since such problems are many and diverse, the lecturer confined himself to an able and thorough consideration of some having special concern for India. In the investigation of these problems he was for long engaged as head of the Research Fund Association of India for the Investigation of Deficiency Diseases, his valuable labours, to great and widespread regret, having come to an untimely end, owing to financial retrenchments. He specially referred to the doctrine of nutrition, and in the exhaustive discussion that ensued, the Society was congratulated upon its success in having the question of diet brought forward by a distinguished authority, who has had so broad an experience and been so fortunate in collecting much evidence over a wide area and among many peoples. More than one of the experts who spoke expressed the hope that those who have scientific research at heart as well as those merely interested as persons desiring to promote the welfare of the Indian people, particularly the "almost voiceless agricultural labourers," will use their influence to obtain a revocation of the decision which interrupted at a small saving the beneficial work that was being so efficiently carried on.

On the recurrence of the decennial census in India, it has long been the privilege of the Society to be favoured with first-hand accounts of that stupendous work from those engaged in planning and carrying it out. Two years ago the Census Commissioner for 1921, Mr. J. T. Marten, set forth the peculiar conditions in which the undertaking of that year was executed, and described some of the more formidable difficulties encountered and overcome. In acordance with precedent, Mr. Marten, during his leave at home in February, contributed a second paper, in which he dwelt on some of the most important problems which emerged from the statistical matter not previously available. He mentioned that the progress of industrialisation in India, which arouses so much public interest, forms a subject of which the census can only touch a fringe, but he expressed the hope that the attempts to form an "industrial census," though so far necessarily imperfect and limited, will lead to a properly organised system and afford much-needed information to students and the administration. In the course of the discussion an enquiry into the Indian economic situation was suggested, Sir Louis Dane observing that he should be much surprised if, as a consequence of such an inquiry, many ideas as to the real poverty of India were not dissipated. Since this meeting the appointment of a small committee to make a preliminary economic survey has been announced.

In his interesting paper, the only fault of which was that the author, to use the words of Lord Chelmsford, the Chairman, was perhaps "too discreet," Sir Henry Sharp gave what he called a brief and bird's-eye view of the history of Indian Universities, the ancient foundations; their decay under the stress of war and anarchy; the handing on of the torch through humbler institutions; the introduction of Western learning under an ordered Government; the inevitable demand for Universities of the Western type to crown the fabric of the new system; their creation in a form suitable to local conditions, but big with potential difficulties; the manner in which those difficulties were remedied and finally the recognition of the need for a supplementary system of local teaching Universities. While he did not generalise about the relative merits and defects of large affiliating Universities and small unitary Universities, he declared that it is in the success of the latter that the future of University education in India mainly rests.

Sir Gilbert Walker, at the outset of his paper on "The Meteorology of India," pointed out that the Indian climate is of special interest, not merely as being that of the greatest tropical region in the British Empire, but also because it seems to have been designed by nature with the object of demonstrating physical processes on a huge scale. Most of the area involved, including the driest of deserts and the steamiest of swamps, is in a great measure isolated from external influence to the north by a mountain barrier which prevents interference from outside with many of nature's experiments, while in Ladak, a western continuation of Tibet, can be observed minimum temperatures actually arctic. Referring to the value to aeronauts of a knowledge of upper air conditions, he said that the struggles in India had, last year, resulted in placing this work on a permanent footing. There is now a well-equipped central observatory at Agra and about eight subordinate stations. The assistance rendered by India in the issue of warnings of storms or strong head winds will, it is expected, be reciprocated by aeronauts. After indicating some of the ways in which meteorology alone is vitally connected with the economic life of a nation, Sir Gilbert reviewed certain developments in co-operation with medicine and other sciences, submitting that an examination of such questions as he referred to are "worthy of the best brains that India can command."

Sir Alfred Chatterton's comprehensive paper illustrated the methods by which an enlightened Native State has endeavoured to solve the problems arising from the industrial conditions prevalent in our Indian Empire. As the Government of Mysore becomes more popular it naturally ceases to be paternal, and in the future "development will rest much more than in the past with private enterprise." The proximity of the Indian Institute of Science, for which the country is indebted to the munificence of the late Mr. J. N. Tata, has, he said, proved of considerable use to the Mysore State, though, perhaps not to the extent that its resources are capable of. But the Institute, over which Dr. M. O. Forster, F.R.S., a former member of the Council of the Royal Society of Arts, at present presides, has been eminently successful in its main object, the training of men to conduct investigations in a scientific way.

In the course of his extensive and not unfruitful travels in Central Asia Brigadier-General Sir Percy Sykes visited such distant and celebrated places as Bokhara and Samarcand. But as he told us in the admirable paper which concluded the meetings of the Indian Section, he was not content and wished to go further in the East and see the mysterious cities of Yarkand and Khotan, as well as the remote uplands of the Pamirs. The opportunity was afforded in 1915, when he was appointed Consul-General for Chinese Turkestan, and he was accompanied on his arduous expedition by his sister, Miss Ella Sykes, also well-known for valued contributions to the Society. One object of the journey was a long cherished ambition to hunt the *ovis poli*. An interesting feature of Sir Percy Sykes's picturesque and superbly illustrated narrative was the description he gave of a visit, *en route*, to the Sarikol Valley, which possesses the extraordinary interest that its inhabitants, followers of His Highness the Aga Khan, are pure Aryans, and, with their aquiline noses and clear-cut features, might be taken for dwellers in South Europe. He mentioned that on the track from the Great Karakul Lake to Pamirski sea shells were noted, proving that the "Roof of the World" was at one time under the sea.

What Mr. Dunlop called "economic research" is, he explained, really economic geography and industrial and administrative efficiency. He illustrated his meaning by contrasting a country poorly off and unable to accomplish full development, British Guiana, with a country prosperous and fairly developed, British Malaya, the dissimilarities being the result of geographical characteristics. The conclusions arrived at by such a comparison are, he held, illuminating and indicate a field for more intensive study throughout the tropical regions of the British Empire. The great motive in studying industrial efficiency is to assist existing populations to get more out of what they already possess. In the United States of America people are beginning to analyse, not only their own territories, but ours, more or less from the points of view put forward by

Mr. Dunlop, who maintained that a systematic study of the British tropics along the lines recommended would not only assist in economic development, but intellectually increase our world prestige, cost very little, and lead in the end to a much better understanding and closer sympathy. The Under Secretary of State for the Colonies, Mr. Ormsby-Gore, who took part in a very interesting discussion, said that Mr. Dunlop had advanced a most valuable and suggestive line of thought on his main point, namely, that hitherto very little has been done in the Empire in the direction he indicated.

The crying need of Tropical Africa to-day, as described by Mr. R. H. Brackenbury in his very important paper, is an adequate system of cheap transport capable of being expanded to meet any reasonable call made upon it by districts which are not served by the railway. A solution of the problem is not to be looked for in head porters, pack animals or even in ox or mule waggons; and the heavier types of motor vehicles, though more suitable than the lighter kinds, are impracticable, owing to the inability to provide the kind of cast-iron road such as is found essential in Europe. But if the roads in Africa cannot be made to suit the vehicles there is every hope that we are making vehicles to suit the roads, or the lack of them! In Mr. Brackenbury's opinion it is to the use of " track vehicles " that we must look for the bridging of the "very large economic gap which comes between the primitive methods developed by the natives themselves, and the highly specialised railway system laid down by the governing European Powers."

The two salient features of the address on the Belgian Congo, which Monsieur Louis Franck contributed to the Society last year, were first, population, and, secondly, transportation. In his excellent paper, "Some African Problems," Mr. Ormsby-Gore, said that everything he had learnt, both during his recent tour through the British territories in East Africa, and by his study, led him to the same conclusion, though he added a third vital subject, namely scientific agriculture. If we are to build up a peasant proprietary in East and West Africa, larger families are an economic necessity, and in this the first concern, governments, planters, traders and native producers are equally interested. He has been driven to consider that the further development of Tropical Africa is essentially bound up with the extension of the railway system, and in view of the depressed state of the industries affected in Great Britain, he feels that this is the time when every effort consistent with native interests should be made to expedite matters. With regard to his final subject, he emphasised the fact that native production cannot possibly succeed in the long run without a considerably augmented staff of European scientifically trained agricultural officers.

Lord Stevenson, in the interesting paper he read before the joint meeting of the two Sections, held in April, devoted himself mainly to giving a useful account of the growth and development of the British Empire Exhibition, from its inception, as far ago as 1913, by that great "Empire builder," Lord

Strathcona, reserving for future treatment the new and improved features that are at present attracting so many people to Wembley. Sir Charles Campbell McLeod, who presided over the large audience, mentioned that, had not Lord Stevenson come upon the scene when he did, it is doubtful if there would have been any Exhibition at all last year.

III.—Cantor Lectures.

The first course of Cantor Lectures was delivered by Dr. Louis C. Martin on "Modern Colour Problems." After discussing the relations of light and colour, and the physical basis of colour vision, the lecturer dealt with the question of producing artificial daylight. The various attempts in this direction were described, from the earliest efforts to the latest developments. The second and third lectures were devoted to the methods of measuring colour and to the various instruments devised to secure accuracy in this measurement.

In the second course Mr. V. E. Pullin took for his subject "Radiological Research—A History." In the first lecture he outlined the part played by each of the numerous workers who have contributed to the discovery and development of X-rays. The second lecture was devoted to a description of the instruments which were used by them; while in the third he dealt with the applications of X-rays and showed how their use in medicine and in numerous branches of industry is increasing almost daily. Almost daily, too, is the improvement in X-ray apparatus increasing, for at the last lecture Mr. Pullin was able to announce that on the previous day, in the Radiological Research Department at Woolwich, they had contrived to take an X-ray photograph through four inches of steel, a feat which had never before been accomplished.

Dr. Walter Rosenhain delivered the third course, under the title "The Inner Structure of Alloys." He described the latest theories as to the atomic structure of crystals, and the possible arrangements of atoms on space lattices. The questions of electrical conduction and of super-conductivity were considered, and theories were advanced as to the way in which these phenomena depend on the arrangement of the atoms. Some reference was made to the colour of alloys, a point to which little attention has hitherto been directed, but the study of which, it would seem, might lead to valuable practical developments in metallurgy. The whole course was a striking illustration of the manner in which the most abstruse scientific theory may be of the greatest possible benefit to industry.

IV.—Howard Lectures.

Under the Howard Trust a course of three lectures on "Motor Fuels" was delivered by Professor J. S. S. Brame. In dealing with the problem of motor fuel supply the lecturer quoted figures to show the enormous and steadily increasing quantity of fuel which is required for use in internal combustion engines. The various kinds of spirit derived from petroleum were mentioned and their characteristic features analysed. The question of the production of alcohol for power purposes was then discussed, together with the problems of storage, handling and fire risks.

V.—DR. MANN JUVENILE LECTURES.

Under the Dr. Mann Trust two Juvenile Lectures were delivered by Lieut. Colonel E. H. Richardson, assisted by Mrs. Richardson. In the first, "Dogs in War," he described the part played by dogs as messengers, as sentries, in laying telephone wires and in ambulance work, such as finding the wounded on the battlefield and bringing the stretcher bearers to their assistance. The dogs were extraordinarily loyal to their duties, and more than once they succeeded in bringing urgent messages through the thickest fire, even after they had been desperately wounded. A great many dogs of all sorts of breeds were used during the war; they were recruited from private owners, Dogs' Homes—wherever they could be obtained; a large training school was established at Shoeburyness, under the charge of Lieut.-Colonel Richardson, and dogs were sent from there to almost all the battle fronts, where they did valuable service and saved many human lives.

The second lecture, "Dogs in Peace," was mainly devoted to the training and work of police dogs, shepherd dogs and bloodhounds. Colonel Richardson strongly emphasised the need of basing the training on affection and companionship between master and dog. Rough treatment ruins that relationship and no satisfactory training can be carried out unless advantage is taken of the dog's anxious desire to co-operate with his master.

Colonel Richardson brought a number of dogs with him to illustrate his lectures, and their presence was greatly appreciated by the juvenile audiences.

VI.—ALBERT MEDAL.

The Albert Medal of the Society for the current year has been awarded by the Council, with the approval of the President, H.R.H. the Duke of Connaught, to Lieut.-Colonel Sir David Prain, C.M.G., C.I.E., M.B., LL.D., F.R.S., "for the application of Botany to the development of the raw materials of the Empire."

Sir David Prain is one of the most distinguished of living botanists. When Director of the Royal Botanic Gardens at Calcutta, he developed the Government cinchona plantations of India, and organised a system for the cheap distribution of quinine through the Post Offices, thereby making the drug familiar in every village of India and saving unnumbered human lives. Subsequently as Director of the Royal Botanic Gardens at Kew his work has been of immense value to those engaged in the trades in timber and in other vegetable products of commercial value. The great importance of his work is appreciated by the scientific world and by Government Departments in this country and in India.

VII.—MEDALS FOR PAPERS.

Eleven medals have been awarded for the papers read before the Society during the current session—seven for papers read at the ordinary meetings, three for those read in the Indian Section, and one for those read in the Dominions and Colonies Section.

The awards are as follows:—

Papers read at the Ordinary Meetings:—

Llewelyn B. Atkinson, M.I.E.E., Past-President of the Institution of Electrical Engineers, "The Scientific Principles of Artificial Incubation."

C. F. Elwell, B.A., "Talking Motion Pictures."

Mrs. Graydon-Stannus, "Irish Glass, Old and New."

Emile Cammaerts, "The Restoration of Belgian Towns."

Claude N. Friese-Greene, "The Friese-Greene Process of Colour Cinematography."

Henry G. Dowling, "Wallpapers."

Lieut.-Colonel Andrew Balfour, C.B., C.M.G., M.D. (Edin.), B.Sc., D.P.H., F.R.C.P.E., "The Trend of Modern Hygiene."

Papers read in the Indian Section:—

Lieut-Colonel R. McCarrison, C.I.E., M.D., B.Ch., B.A.O. (R.U.I.), LL.D., D.Sc., F.R.C.P., Indian Medical Service, "Problems of Food, with Special Reference to India."

Sir Henry Sharp, C.S.I., C.I.E., M.A., "The Development of Indian Universities."

Sir Gilbert T. Walker, C.S.I., M.A., Sc.D., Ph.D., F.R.S., F.R.A.S., "Indian Meteorology."

Paper read in the Dominions and Colonies Section:—

R. H. Brackenbury, Member of the Empire Cotton Growing Corporation Mechanical Transport Sub-Committee, "Transport in Tropical Africa."

For many years it has been the practice that no medals should be awarded to members of the Council, or to readers of papers who have previously received medals from the Society. Acting on this rule the Council were precluded from considering the following papers:—

Colonel R. E. Crompton, C.B., R.E., M.Inst.C.E., M.I.E.E., etc., "The Motor Car, its Birth, its Present, and its Future."

Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., "The Power of Internal Combustion Engines for Motor Cars."

Professor John Ambrose Fleming, M.A., D.Sc., F.R.S., "William Sturgeon and the Centenary of the Electromagnet."

Brigadier-General Sir Percy Sykes, K.C.I.E., C.B., C.M.G., "The Heart of Asia and the Roof of the World."

The Council desire, however, to express their high appreciation of these papers.

VIII.—PETER LE NEVE FOSTER PRIZE.

The late Mr. Reginald Le Neve Foster presented the Society with a donation of £140 for the purpose of founding a prize in commemoration of his father, Mr. Peter Le Neve Foster, who was Secretary of the Society from 1853 to 1870.

The Council last year offered a prize of £25 for an essay on "The Effect of Trade Union Regulations on Industrial Output."*

At the request of the Council, Lord Askwith, the Rt. Hon. George N. Barnes and Mr. W. L. Hichens consented to act as judges.

A considerable number of essays were submitted, and as soon as the result of the competition is known, it will be published in the *Journal*.

* The conditions were printed in the *Journal* of October 31st, 1924, page 849.

IX.—THOMAS GRAY MEMORIAL TRUST.

Under the will of the late Mr. Thomas L. Gray, the Society was appointed residuary legatee of the testator's estate for the purpose of establishing a memorial of his father, Thomas Gray, C.B., Head of the Marine Department of the Board of Trade. The main object of the bequest is "the advancement of the science of navigation and the scientific and educational interests of the British Mercantile Marine."*

Up to the present the sum of £4,000 has been handed over by the executors to the Society, and this has been invested in 3½ per cent. Conversion Loan. The Council have appointed a Committee to consider in what way the objects of the Trust can best be carried out, and as soon as they have approved a scheme, full particulars will be published in the *Journal*.

* Further particulars of the bequest were published in the *Journal* of January 23rd, 1925, pages 241-3.

X.—FOTHERGILL PRIZE.

Under the Fothergill Trust the Council have offered a Prize of £100 for an essay on "Fire Waste (Loss of Property by Fire) and its Effects on the Economics of National Life in Great Britain." The last date for receiving the essays is July 31st, 1926. Particulars of the Competition were published in the *Journal* of March 8th last.

XI.—ANNUAL COMPETITION OF INDUSTRIAL DESIGNS.

The second Annual Competition of Industrial Designs will be held at the Victoria and Albert Museum in July next, by kind permission of the Director.

This year the competition is being held in the following sections:—Architectural Decoration (where a Travelling Scholarship of £150 is offered); Textiles (where two Travelling Scholarships are offered); Furniture; Book Production; Pottery and Glass; and Miscellaneous. In the last section a number of prizes up to the value of £50 each are offered by various firms for posters, designs for boxes, etc. The last date for receiving entries is June 24th.

At the first competition, held in 1924, over 1,300 designs were received from about 500 competitors. This year the numbers will probably be considerably more than doubled.

The Council were gratified to learn that the Scheme had been brought to the notice of the Board of Education, who were very favourably impressed by its practical and valuable nature. The Board believe that the competition will have a powerful and beneficial effect on the teaching in Government Schools of Art, and at their suggestion the Council invited them to nominate a representative to serve on the Central Committee of the Scheme. Mr. Henry Allport, H.M. Inspector of Art Schools, has been appointed accordingly.

It has been the aim of the Council and of the various committees appointed by them to carry out this competition, to ensure that any designs approved by them should bear evidence that the designers possess not only exceptional artistic ability, but also a sound and practical knowledge of the materials and processes of their trades. The various committees consist mainly of representatives of important manufacturing and commercial firms, and the judges nominated by them will not be likely to overlook the question as to whether a design submitted is suitable or not for the materials for which it is intended.

After the awards have been made, it is intended to exhibit a number of selected designs at the Victoria and Albert Museum, as was done last year; possibly, also, exhibitions will be held at suitable centres outside London, where the designs will be brought to the notice of manufacturers likely to be specially interested in them.

As soon as the Judges have completed their work it is proposed to issue a full report on the competition,* which will be published in the *Journal* and circulated widely among manufacturers and competitors. It is hoped that this report will be of great service to young designers and to the industries concerned. The judges will be able to criticise the work submitted, to show wherein it is defective, either from the artistic or practical point of view, and to point out the lines along which development is to be encouraged.

* The Report on last year's Competition was published in the *Journal* of August 22nd, 1924, pages 689-696.

XII.—EXAMINATIONS.

The number of entries for this year's examinations again constitutes a record. For the first series the figure was 27,568, for the second series 46,778, making a total of 74,346, as against 71,111 in 1924.

In order to show their growth the figures are given for the last seven years.

Year.	Number of entries.	Year.	Number of entries.
1919	34,173	1923	68,241
1920	54,010	1924	71,111

1921	55,182	1925	74,346
1922	60,331		

The examinations are held in most of the principal cities and towns of Great Britain and Ireland, and in nearly all cases are conducted and supervised by the Local Education Authorities, to whom the Society is greatly indebted for the efficient manner in which these duties are carried out.

There were 366 Centres for the April Examinations, and 360 Centres for those in May and June. The County of London, where the Examinations are under the supervision of the London County Council Education Committee, is only reckoned as one Centre, though under this head are included entries from nearly two hundred Evening Institutes, Central Schools, Polytechnics, Proprietary Schools, etc. The number of entries for the County of London was 3,152 in April, and 14,809 in May.

The liberality of the Worshipful Company of Clothworkers has enabled the Council, as in past years, to offer the usual silver and bronze medals. These medals are very highly valued by the successful candidates, and they contribute not a little to maintain the high standard of the examinations.

The results of the first series of the Examinations have already been communicated to the candidates, and those of the second series will be announced as soon as possible.

A report giving full details of the year's Examinations will be published in the *Journal*, as usual, at a later date.

XIII.—ORAL EXAMINATIONS IN MODERN LANGUAGES.

The Oral Examinations are still in progress in various parts of the country. Particulars will be given in the annual report on the Examinations.

XIV.—NEW COUNCIL.

The Vice-Presidents retiring under the ordinary regulations are: Sir Herbert Jackson, The Hon. Sir Charles A. Parsons, Mr. James Swinburne, and Sir Philip Watts. Two further vacancies were caused by the deaths of Marquess Curzon of Kedleston and Viscount Leverhulme. In their places the Council recommend Viscount Burnham, Viscount Cowdray, Sir Robert Kindersley, Sir Charles C. McLeod, Sir George Sutton and Sir Charles Wakefield.

The four other members of the Council retiring are: Mr. A. Chaston Chapman, Colonel Sir Arthur Holbrook, Sir Charles C. McLeod and Sir George Sutton (of whom the last two are recommended as Vice-Presidents). In their places the Council recommend, Mr. Llewelyn B. Atkinson, Sir John H. Biles, Sir Edward Davson and Professor J. M. Thomson, none of whom have served on the Council in any capacity during the last year.

XV.—OBITUARY.

During the last twelve months the Society has lost a number of very distinguished Fellows, of whom no fewer than five were serving on the Council at the time of their deaths.

Marquess Curzon of Kedleston joined the Society in 1895, and he was a Vice-President and a member of the Indian Section Committee when he died.

Viscount Leverhulme was also a Vice-President of the Society, and was among those who assisted in starting the Fund for purchasing the Society's House, his contribution being £1,000.

Lord Blyth was a member of the Society for over forty years, and he served on the Council in various capacities for twenty years.

Sir Steuart Colvin Bayley was Chairman of the Council from 1906-08. He also did valuable work on the Indian Section and Finance Committees.

Sir Thomas Jewell Bennett was an active member of the Indian Section Committee and of the Council.

Mr. John Slater was a very useful member of the Council and rendered the Society valuable service when the house was being renovated.

Sir George Beilby had been a member of the Society since 1884. He had served for several years on the Council, from which he had retired shortly before his death. He contributed £500 to the Fund for purchasing the Society's House.

Sir Harry Veitch had been a Member of the Society for fifty-three years, having been elected in 1871.

Professor George Downing Liveing had also been a Member of the Society for over fifty years, having been elected in 1874.

Mr. William Whitaker was another Fellow of old standing, his election dating from 1886.

Among other notable Fellows of the Society who have died during the last year may be mentioned the Rt. Hon. Sir William Grey Ellison-Macartney, Sir Marshall Reid, Mr. George Watt Christison, Colonel Malcolm H. Crump and Mr. C. H. Wordingham.

Obituary notices of these have appeared in the columns of the *Journal.*

XVI.—FINANCE.

The financial statement for 1924, published in the *Journal* of June 19th, 1925, shows that the excess of income over expenditure for the year ending December 31st, 1924, was £974 4*s*. 7*d*. The corresponding figure for the previous year was £1,383 13*s*. 8*d*., and for 1922, £596 17*s*. 4*d*. In 1923 the interest on the Bank overdraft was charged to the Building Fund Account. To facilitate the book-keeping, this account has now been closed, and the amount of the interest, £289 16*s*. 5*d*., appears on the debit side of the Income and Expenditure Account.

The item of expenditure, "Industrial Art Committees, £148 14*s.* 9*d.*," includes the cost of printing, postage and labour in connexion with the Competition of Industrial Designs held at the Victoria and Albert Museum in 1924.

On the whole, the Council are of opinion that the situation shown by the Income and Expenditure Statement for 1924 is satisfactory. There is, however, still a deficit of nearly £7,000 on the Building Fund. If this fact is brought to the notice of the Fellows, the Council feel confident that it will act as an incentive to them to assist in wiping off the deficit.

MR. R. à ABABRELTON moved the adoption of the Report. The motion was duly seconded and the Report was adopted.

THE CHAIRMAN (Sir Charles S. Bayley) then proposed a cordial vote of thanks to Mr. G. K. Menzies (the Secretary), Mr. S. Digby (the Secretary of the Indian and Dominions and Colonies Sections), Mr. George Davenport (the Chief Clerk), Mr. J. H. Buchanan (the Accountant and Examinations Officer) and to the other officers of the Society for their services during the year.

The motion, having been duly seconded, the vote of thanks was carried unanimously.

The ballot having remained open for half-an-hour, and the scrutineers having reported, the CHAIRMAN declared that the following had been elected to fill the several offices. [The names in *italics* are those of Fellows who have not, during the past year, filled the office to which they have been elected.]

PRESIDENT—H.R.H. The Duke of Connaught and Strathearn, K.G.

VICE-PRESIDENTS—Sir Charles H. Armstrong, Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I., Viscount Bearsted, LL.D., Captain Sir Acton Blake, K.C.M.G., K.C.V.O., *Viscount Burnham, C.H., LL.D.*, *Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., *Viscount Cowdray, G.C.V.O.*, Earl of Durham, K.G., P.C., G.C.V.O., Peter MacIntyre Evans, M.A., LL.D., Sir Edward A. Gait, K.C.S.I., C.I.E., Viscount Inchcape, G.C.S.I., G.C.M.G., K.C.I.E., *Sir Robert Kindersley, G.B.E.*, *Sir Charles C. McLeod, Bt.*, Col. Sir A. Henry McMahon, G.C.M.G., G.C.V.O., K.C.I.E., C.S.I., Sir Philip Magnus, Bt., Senatore Guglielmo Marconi, G.C.V.O., LL.D., D.Sc., *Sir George Sutton, Bt.*, *Alan A. Campbell Swinton, F.R.S., J. Augustus Voelcker, M.A., Ph.D., *Sir Charles Wakefield, Bt., C.B.E.*, Sir Aston Webb, G.C.V.O., C.B., R.A., *Sir Henry Trueman Wood, M.A., Sir Alfred Yarrow, Bt., F.R.S., M.Inst.C.E.

ORDINARY MEMBERS OF COUNCIL.—*Llewelyn B. Atkinson, M.I.E.E.*, Sir Frank Baines, C.V.O., C.B.E., *Sir John H. Biles, K.C.I.E., LL.D., D.Sc.*, Sir William Henry Davison, K.B.E., D.L., M.P., *Sir Edward Davson*, Sir Archibald Denny, Bt., LL.D., Sir Robert Abbott Hadfield, Bt., D.Sc., F.R.S., Rear-Admiral James de Courcy Hamilton, M.V.O., Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., Major Sir Humphrey Leggett, D.S.O., R.E., *Professor J. M. Thomson, F.R.S.*, Sir Frank Warner, K.B.E.

TREASURERS—Lord Askwith, K.C.B., K.C., D.C.L., Carmichael Thomas.

SECRETARY—George Kenneth Menzies, M.A.

On the motion of the CHAIRMAN a vote of thanks to the scrutineers was carried unanimously.

*Nominated by H.R.H. the President.

Mr. R. à-**Ababrelton** said there was one small point on which he would like to offer an observation. Up to November last the *Journal* was printed in type so small that some Fellows complained that it was difficult to read. Considerable alterations were then made in the style of producing the *Journal*. There was, no doubt, a great improvement, but, unfortunately, also a considerable increase of expense, with the result that it was sometimes necessary to condense the discussions on the papers. He thought it should be possible to find a smaller type which should yet be quite clear, and this might enable the printers to put more matter into the *Journal* without increasing the number of the pages.

The **Chairman** stated that the question of the *Journal* was always present in the minds of the Council and that they were glad to have any suggestions that might lead to its improvement.

The meeting was then adjourned.

CORRESPONDENCE.

THE TREND OF MODERN HYGIENE.

Your issue of 29th May contains an interesting report of a paper by Dr. Andrew Balfour and of the discussion. Sir George Newman, who was in the Chair, referring to Jenner and Vaccination, said that " the lesson of Jenner had been copied throughout the world, and as far as he knew had never failed."

In India the population under British rule has been vaccinated for the last hundred years, and the number of annual vaccinations considerably exceeds the number of annual births. Yet every year from fifty thousand to a hundred and thirty thousand persons die of smallpox. Various medical authorities in India have recorded that vaccination in India has no effect on endemic or epidemic smallpox.

In England and Wales vaccination was made compulsory in 1853, and was sternly enforced, and by the year 1870 about eighty-five per cent. of the babies born were vaccinated, so that about ninety-seven per cent. of the children living at that date had been vaccinated, as well as a very large proportion of the older people. In the years 1871 and 1872 there was the most fatal smallpox epidemic that has ever been known in the British Isles. More than forty-three thousand people died of this disease.

Sir George Newman also said: "Yet there were last week 168 fresh cases of smallpox." I will add to that statement that in the first fourteen weeks of 1925, 1609 cases were notified as smallpox, and there were two deaths from smallpox in that period, which is a very small proportion, especially considering that there were between two thousand and three thousand cases notified as smallpox in the year 1924.

Sir George Newman also says: " The Schick Test of diphtheria was another example. It was practised in New York, where it was used as an instrument of prevention, direct and immediate, on an enormous scale."

This is a curious statement because it appears to be in contradiction to statements in a book recently issued by the League of Nations, written by an eminent Belgian medical man (Dr. Louis Van Boeckel, Director of the Laboratory of the Belgian Public Health Department), who visited the United States in order to examine into the practice of the Schick Test. From this it appears that the Schick Test was not found to be reliable and was to a great extent abandoned in the United States. The advocates of the Schick process preferred to omit the Test and to inoculate all the children with what they called toxin anti-toxin. But the report of the Belgian doctor also seems to show that there is great uncertainty as to the results of this toxin anti-toxin, and the children to whom it has been given have to be tested once a year to see if they are still protected. A reference is given to the case of two thousand to whom the toxin anti-toxin was given to make them safe against diphtheria, but when they were tested it appeared that they were not safe. Inoculation with toxin anti-toxin by itself appears to be a serious matter and to produce a great amount of illness. When the illness is fatal it is referred to as an " accident." But it would seem to me that " accident " is hardly the right word to use. It is known that the stuff is dangerous and it is deliberately applied. Sir George Newman is now advocating the Schick Test in England. I suppose that is because the anti-toxin treatment of diphtheria, introduced about thirty years ago, has been proved to be a failure, else if it were a remedy for diphtheria why start poisoning many children for the sake of the comparatively few cases of diphtheria ?

ARNOLD LUPTON.

NOTES ON BOOKS.

A STUDENT'S MANUAL OF ORGANIC CHEMICAL ANALYSIS. By Jocelyn Field Thorpe, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., and Martha Annie Whiteley, O.B.E., D.Sc., A.R.C.S., F.I.C.

The principles which have guided the authors in the preparation of this manual are to some extent set forth in the introduction, which contains an interesting reference to the different effects produced on the student's mind by inorganic and organic chemistry.

After an opening chapter on the detection of elements, and a short section on the purification of substances, the quantitative estimation of elements is dealt with in a particularly full and satisfactory manner, considerable attention being paid to the history of the subject. The reactions of the commoner organic substances are next systematically described, in which connexion it may be worth pointing out, as a small detail, that in the reference to the microscopic examination of osazones, the student is given no hint as to the magnification to be employed, nor is this quantity noted on the accompanying photo-micrographs.

There follows now an admirable section on the detection and estimation of typical radicles, in which reference is made in almost every case to the original paper describing the estimation. The book is completed by a chapter giving advice on the separation of mixtures and examinations of the constituents, and an appendix on the micro-analytical method devised by Pregl.

Needless to say, there could hardly be a more fertile field for controversy than the method of initiating students in the practice of qualitative analysis, whether organic or inorganic. What the student naturally demands (and what he must continually be told he cannot have) is a cast-iron schedule whereby, after a number of simple " tests," he arrives at the name of the substance to be identified and enters it triumphantly in his note-book. The somewhat deplorable results produced by text-books in the past in the attempt to satisfy this demand are a matter of common knowledge, and some reference is made to this point by the present authors in their introduction.

It is conceivable, however, that in a just reaction fron this state of affairs, and in the attempt to avoid cramming, the modern treatment may throw the student rather too much on his own initiative in the matter of systematic procedure. Much, of course, depends on the supervision, the place of which cannot be taken by any text-book; but the most tireless and lynx-eyed demonstrator will have his time fully occupied, as a general rule, by attempts to elucidate the exact errors in procedure which have led students into difficulties.

THE CHEMICAL COLORING OF METALS AND ALLIED PROCESSES. By Samuel Field, A.R.C. Sc. Lond., F.C.S., and Samuel Robert Bonney. London: Chapman and Hall. 10*s.* 6*d.* net.

This excellent manual, the work of two members of the staff of the Northampton Polytechnic Institute of London, brings together a collection of the kind of information which usually has to be obtained in small fragments from diverse sources.

In metal-finishing the group of chemical processes known collectively as "corrosion" is at once an enemy and a friend: it attacks the finished surface, but in many cases it also constitutes the means by which the finish is produced, and it is thus very necessary that the operator should have a working knowledge of the means by which such processes can be promoted and checked. Some account of the theoretical aspect of this question is therefore given at the beginning of the book, but unfortunately the problems involved are amongst the most obscure of those which engage the attention of the physical chemist, and one may doubt whether a general introduction to chemistry, occupying 28 pages, is a reasonable preamble to a discussion of this sort. The section on aërial corrosion itself is an admirable elementary exposition, though it is probable that more references to sources of additional information would have been appreciated.

The authors then deal with the preparatory processes of mechanical polishing and chemical cleaning. The polishing chapter, although mainly practical in character, nevertheless leaves the uninformed reader in the dark on some very practical points, amongst which may be mentioned the running speed of the bobs and mops, and the means by which they are attached to the polishing spindle.

After a useful chapter on lacquering, we find a section devoted to electro-deposition, a process which in many cases necessarily precedes the actual "coloring," which is next dealt with and which occupies the main part of the book.

Copper and its alloys are of course the most important metals from this last point of view, though silver and iron are also very commonly treated in various ways. An excellent selection of recipes and processes is given, with sufficient practical detail to make them of real value; although, as the authors take care to point out, certain personal qualities in the operator are necessary for complete success. Other metals are not neglected, and separate sections are devoted to the coloring of gold, zinc, nickel, tin and aluminium, the latter being on the whole a disappointing material.

Not the least important chapters in the book are the last two, treating of various processes and general repairs, wherein the best-informed reader will find matter of interest and instruction.

WIRELESS. By P. J. Risdon. London and Melbourne: Ward, Lock and Co., Ltd. 6*s.* net.

The enormous popularity of "wireless" is responsible for the creation of hordes of amateur electrical engineers. To these Mr. Risdon's book should prove a boon, for it is written in clear and simple language, and does not scare off the beginner by plunging him into abstruse technicalities before he has the necessary knowledge to understand them. At the same time the exposition of the subject is very sound, and is of such a nature that it should inspire many of the readers of the book with a desire for a deeper understanding of the scientific theory of wireless telegraphy. The treatment is very full: the author describes all the types of instrument commonly in use, and the very numerous illustrations make it easy to understand the text.

Professor J. A. Fleming, to whom wireless telegraphy is indebted for that epoch-making invention, the thermionic valve, contributes an interesting introduction in the course of which he summarises the history of wireless invention from the first suggestion of Clerk Maxwell as to the possibility of producing electro-nagnetic waves, down to the latest researches of Senatore Marconi in the matter of short-wave beam transmission. Readers of the *Journal* should be familiar with these recent developments, as the Chairman of the Council has within the last twelve months delivered two addresses in which he communicated the results of his investigations.

MECHANICS OF TEXTILE MACHINERY. By W. A. Hanton. London: Longmans, Green and Co. 12s. 6*d*. net.

Mr. Hanton gives us a thoroughly useful and practical book of study or reference likely to be of service to every one who is interested in our textile industries, but it must be clearly understood that the book under notice is not a handbook of textile machinery in the ordinary sense, but rather an encyclopædia of the fundamental concepts which are embodied in the multitude of highly complex and varied machine constructions that are to be found in textile mills.

These primary concepts are admirably presented to the reader in four important aspects: (1) Good indexing, without which a work of this character would rather tend towards worry and vexation than good service. (2) Remarkably full and satisfactory illustration which not only elucidates in detail, but often catches the eye in turning over the pages, showing at a glance whether the index has functioned truly. (3) Description in the text. Concise and exact. (4) Mathematical treatment. This is here and ought to be rather a degree or phase of illustration, than a distinct or specific aspect only of service to the expert and formally trained mathematician.

The good qualities of Mr. Hanton's book in relation to the above-mentioned four aspects are illustrated by this sequent story.

We mentally sought a word by which to test the index, and as good balancing is a fundamental condition in heavy high speed machinery for treating fragile materials, this word was selected as a test for the index. The index gave "revolving masses, 33," and "reciprocating masses 37." Thus aided by the index, our search was actually ended, not by the sight of a page number, but by a view of six diagrams, evidently bearing on the theory of balancing (pp. 36-37). Not theory alone, as one of the diagrams shows the relation of the rest to the picking tappets, the weft fork-tappets and other delicately acting parts. The text is in short well considered sentences and is so distributed among the diagrams and the mathematical expressions so as to explain matters easily to the busy man. There are no massed mathematical sequences, but rather short expressions with explanatory text between: a very real merit in a technical book, as a completely non-mathematical reader can realise the general sense.

Mr. Hanton's work is a good example or pattern to writers of technical books, and a reference book which should be in each department of every textile mill of our Empire.

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FRIDAY, JULY 10, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICE.

THOMAS GRAY MEMORIAL TRUST.

Under the will of the late Thomas L. Gray, the Royal Society of Arts has been appointed residuary legatee of his estate for the purpose of founding a memorial to his father, Thomas Gray, C.B., who was for many years Assistant Secretary to the Board of Trade (Marine Department).

The objects of the Trust are " the advancement of the Science of Navigation and the scientific and educational interests of the British Mercantile Marine." Various suggestions were made by the Testator as to the methods by which these objects could best be promoted, and of these the Council of the Society have now approved the following :—

The offer of prizes for essays of exceptional merit on subjects laid down by the Council which, in its opinion, bear on Navigation and generally are in accordance with the ideas of the testator ;

or, if the Council in any year shall so decide, as alternative or in addition to the above :—

(1) The offer of prizes for exceptional success in classes in Navigation in courses of study approved by the Council.

(2) The making of grants in aid of scientific research connected with the subject of Practical Navigation to investigators approved by the Council.

(3) The giving of awards to any persons who, in the opinion of the Council, shall introduce improvements in the Science or Practice of Navigation.

The Council now offer a Prize of £100 for an essay on the following subject :—

A description of a voyage, with special reference to the questions of stability, rolling and pitching of seagoing vessels, and to the methods of determining the position of a ship approaching and making the land during thick weather.

> The writer should take into consideration the many modern aids to Navigation, and describe the appliances used and their practical effect. He should also describe the methods employed in a vessel fitted with the ordinary equipment which every ship should carry, and include notes on steering, either with the ordinary or with the gyro compass, or both. The whole essay should be based on the writer's personal experience.

Competitors must send in their essays not later than December 31st, 1926, to the Secretary, Royal Society of Arts.

The essays must be typed or clearly written. They must be sent in under a motto, accompanied by a sealed envelope enclosing the author's name.

The Judges will be appointed by the Council.

The Council reserve the right of withholding the Prize or of awarding a smaller Prize or Prizes if, in the opinion of the Judges, no suitable essay is submitted.

The Council also reserve an option on the copyright of the successful essay.

G. K. MENZIES,
Secretary.

PROCEEDINGS OF THE SOCIETY.

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TWENTY-THIRD ORDINARY MEETING.

WEDNESDAY, MAY 27TH, 1925.

SIR ROBERT A. HADFIELD, BT., D.Sc., F.R.S., in the Chair.

The paper read was:—

THE UNEMPLOYMENT PROBLEM.

BY THE RIGHT HON. SIR ALFRED MOND, BT., M.P.

I feel that it is quite unnecessary for me to apologise for bringing before this Society this afternoon the problem of unemployment in this country. The present industrial and economic condition of Britain is so serious and has penetrated into so many different channels, through so many different homes, and in so many different directions, that every one is fully seized to-day of the crisis through which we are passing. It is a subject which has occupied economists, statesmen, and writers now for a number of years. It has occupied me in a special way because I had the honour, when I was in Mr. Lloyd George's administration and was Minister of Health, to be Chairman of the Cabinet Unemployment Committee for some time; and, of course, we were faced with an even worse position then than the one which is before us to-day. At that time our figure of unemployment was over 2,000,000. We anxiously explored and set in operation a good many schemes and methods whereby we endeavoured to alleviate the unemployment situation; some of these I shall refer to later in my lecture, and many of them have, no doubt, contributed considerably to alleviate our difficulties.

In spite of what has been done, however, no one can be satisfied with the present position. I have never been satisfied with the position, whether I have been in office or out of office, and the proposals which I intend to elaborate to you this afternoon were first set out by me and placed by me before my colleagues in the year 1922. It was just at the end of our tenure of office, so that the discussion on them was interrupted at that time, and although I have now adumbrated and spoken and written about them more than once since then, one has always hoped that the normal restoration of industrial prosperity would make it unnecessary to enter upon what I frankly admit is a difficult task, that of introducing any scheme which is in the nature of some form of subsidy.

Those hopes have not been realised. Those anticipations of amelioration have not really been fulfilled. We have reached a kind of static position of unemployment going on year after year, month after month. A heavy veil seems to obscure our view of the future prosperity of our country, and it shows no sign of lifting. Therefore, I have come back once again to impress on all those interested in the subject, all who have authority, all who feel as I do the impossibility of sitting still and doing nothing, the adoption of a scheme which I will develop before you. It is a scheme which has had the most careful reflection, the most critical examination, and after listening to many arguments and objections I still believe it to be the only scheme which is likely to do anything on a considerable scale to return the workless to their work.

Before entering upon the details of the scheme it will be well for us to try and envisage our problem from the widest point of view. I am not going to inflict upon you this afternoon the large amount of statistical data I have collected. I have no doubt that if this statistical matter appears in the Transactions of the Society, those who are interested in the details and figures will have ample opportunity of studying them at their leisure. But these figures, which are all taken from official sources and, therefore, can readily be checked, are sufficiently striking even if they are taken only in their broadest outline. They refer to Great Britain and Northern Ireland. In July, 1924, the estimated number of persons under the National Health Insurance Act was 11,514,000. The number of unemployed books remaining lodged on April 27th last was 1,292,130; the percentage of unemployed, therefore, was 11.2. The industries with over 20,000 persons unemployed were the following:—

Coal mining	146,133
Steel	55,370
Engineering	81,902
Shipbuilding	80,225
Cotton	40,158
Wool and worsted	43,200

Linen	29,126
Building	59,918
Public works contracting	23,259
Road transport (other than tramways and omnibus services)	22,099
Shipping services	25,049
Canal, river, dock and harbour services	60,819
Distributive trades	96,871
Local Government	21,140
Hotel, boarding house, and club services	33,046
Other industries and services	29,205

This makes a grand total of 847,520. In these 16 industries, out of the total of 100 in the Ministry of Labour classification, we find 66.6 per cent. of the existing unemployment.

Now take industries in which unemployment is 30 per cent. or above :—

Tin plates	36.8 per cent.
Shipbuilding	31.4 „
Linen	33.1 „
Canal, river, dock and harbour services	31.4 „

Then we have steel, which has 26.7 per cent., and we have a number of other industries—in which the percentage of unemployment is between 20 and 30 per cent. of the total number registered in those industries—of which shipping services is the largest, giving altogether 23.2 per cent. of total unemployment. We have twenty-one industries in which unemployment is between 15 and 20 per cent., and fifty-one in which it is between 10 per cent. and 15 per cent. These last include coal-mining, which, in spite of the large number of its unemployed—146,133—has a ratio figure only of 11.6 per cent. Finally, we have a total of 417,923 unemployed, in 49 industries, in which unemployment is below 10 per cent. These include :—

Cotton	7.1 per cent.
Building	8.3 „
Distributive trades	7.2 „

What do these figures teach us, and what is the object of examining them ? It is to show us that what one might call mass unemployment is confined to a relatively small number of industries, though industries by no means small in magnitude. There is a very heavy weight of unemployment in a certain number of industries, a more moderate weight in a larger number, and a relatively normal rate in the bulk of the industries coming under the classification. We have seven industries which alone account for 41.7 per cent. of the total unemployment. If any action could be taken to help these industries out of the rut they have fallen into, it would have an immediate and marked effect on the total unemployment returns, and, more than that, it would tend to reduce the unemployment in a very large number of ancillary trades.

Speaking on this subject once, I described the position as like that of a stone thrown into the middle of a pond. There is a big splash, and gradually the water ripples out in wave after wave till the disturbance is almost lost to sight, though not to scientific measurement, as the impact diminishes, and the waves become less and less. If you can make a break in the depressed conditions of large industries it is obvious that the economic effect must be to "ripple out" ancillary employment through a dozen, a hundred, a thousand channels, almost imperceptibly, almost without the observer being able to say exactly how much of the improvement is due to the action which has been taken, and yet quite obviously, to all who will give it a moment's thought, a case of cause and effect.

There are those who have objected to some of my ideas on the ground that if such a scheme were introduced it would affect only a small number of industries, and might not be of much avail even in those. Criticisms of that kind always omit what may be called the "snowball" effect. It is forgotten that the stimulation of any part of the social organism must cause reactions in many other parts, and, indeed, almost throughout the whole structure of society.

The next point we might examine with some profit is the question of certain of the causes which have produced the present state of unemployment. There are a variety of causes, of which most of you, probably, are fully aware. There is no reason, for all that, why we should not re-examine them so as to get a clear picture of the whole position. Let us take first industries increased beyond their normal capacity on account of war expansion. Of these the largest group is the heavy metal industries—pig iron, steel, iron and steel tube making, and other metal industries. There we find a heavy rate of unemployment:—

Pig iron	20.4 per cent.
Steel	26.7 "
Iron and steel tube making	18.8 "
Other metal industries	11 "

The total number of unemployed in these industries is 85,994. Then we have:—

Engineering	81,902
Shipbuilding and repairing	92,334
Shipbuilding services	25,049

The total number is 287,279. This group of industries represents 22.2 per cent. of the total unemployment, and it is a group in which, as we all know, a great deal of expansion went on for war purposes. Factories were put up, yards were built, plant was extended in order to meet the requirements of the war, with the result that, not only in this country, but in all the countries of the world, there is an enormous number of plants in existence for peace requirements. This is a cause of depression which can only gradually pass away as the consumption power of the world goes up to its usual capacity. It is not only a national but an international phenomenon.

Then we have industries which have been seriously affected by the loss of foreign markets—especially I refer to coal mining. Anybody who knows anything about the coal trade is aware of the great loss of our export coal trade during the last few years. This is due to a variety of causes, such as electrification in countries where water-power is cheap, the substitution of oil fuel both on land and still more on sea in place of our steam coal, the development of new coal-fields and collieries elsewhere, especially the great development of lignite or brown coal in Germany. That gives you part of your clue to the figure of 146,000 unemployed at present in the coal mines. In the textile trades we find also, if not similar, some analogous conditions. In the cheaper and lower grades of textiles we have lost a great many markets to countries where lower wages are paid and longer hours worked. These two industries, coal-mining and textiles, represent 24.4 per cent. of total employment.

Then we have a whole string of industries, not large in themselves, but adding up to a considerable total, which depend mainly upon what I may call the general prosperity of the country, representing 46.9 per cent. of total unemployment. That is another illustration of the interdependence of one class of industry on the others. Of course, there are many more causes than those I have just enumerated for our depressed industry, and especially our depressed export trade. We have pursued a financial policy which, admirable in itself, and perhaps in the long run the best we could have adopted, must have an immediate effect, like all policies of deflation, leading to depression of industry and, in consequence, unemployment. I do not think that general proposition would be denied by any economist in the world. The result is to give what might almost be called an artificially created unemployment in this country by reason of the financial policy we have pursued.

Again, the deterioration of foreign exchanges, which operates in exactly the opposite direction to the course we have been taking, makes our entry into these markets almost an impossibility. The highest tariffs which the most ardent protectionists have dreamed of are moderate in comparison with the artificial tariff which is set up through depreciated exchanges in so many countries of Europe to-day.

Then the war itself naturally brought about the creation almost all over the world of factories and industries to supply internally goods for which the country formerly relied upon imports coming from our own and from other European countries. The supply of those goods from the usual sources was cut off during the war, and naturally the people who could not get the goods to which they had been used started an effort to get them for themselves. Factories once started are rarely abandoned. No nation likes to see industries which have once begun being scrapped again. They prefer tariffs or subsidies to seeing factories closed and the people in their midst thrown out of work. Thus we have to face the fact that people who have been used to buying from us now manufacture for themselves.

There is a further factor—that of cost. All wars throughout history, whatever period be taken, have always caused impoverishment of the world, never enrichment. This has been the ruin of most of the great empires of the past. It has been the cause of the destruction of most of the great civilisations we have known. If war has always resulted in a general impoverishment of nations, it is obvious that war on a scale unprecedented in area, number of combatants, and cost, must leave behind it an impoverished world, and that being so we have a reduced purchasing capacity and a lower standard of living, not because of want of demand, but because of want of capacity to meet the demand in most of the countries of the world. We suffer from this factor even more than other countries, for consider what is our strength in industry, and generally in manufactures. It is quality rather than cheapness, and quality is expensive. British goods always come into favour when people have money to spend on good things, and they fall out of favour when people are poor and have to buy cheaper goods. Great Britain cannot at once be the loom of the world and also the ready-made clothing establishment, and, therefore, in a question of prices we suffer more than other competitors.

I have given you a broad outline of the picture at which we have to look. To sum it up, we have a volume of unemployment of which the figure 1,292,131 unemployed as returned under the unemployment scheme, with which we are familiar, does not represent entirely the total unemployment in this country. Agriculture and domestic service, for instance, do not fall within the categories of the Unemployment Insurance Acts at all, and there must be some percentage of unemployment in those industries. The insured industries represent only 47 per cent. of the total population above the age of sixteen. Therefore, to the Ministry of Labour figures of one and a quarter million unemployed, we must add several hundreds of thousands in order to get to the total unemployment, and if the result be worked out on population we get to a figure of something like one-tenth of the whole population dependent on unemployment benefit, poor law-relief or charity for their sustenance.

Nobody can say that this is a satisfactory position for any country to be in. No one can say that this is a thing which can be allowed to go on indefinitely eating into the material sustenance and the moral life, the very heart of the nation, without the most serious misgivings and possibly the most serious consequences. Therefore, I am myself surprised—in fact, sometimes I find it difficult to realise—that the great mass of the people of this country, having seen this state of things, seem to be content to let Governments come in and go out, to let Ministers stand at the table and make vague statements about what they are considering to do, and do not insist for their own safety and salvation that this is the one problem on which all attention ought to be concentrated. People have seen this state of things remaining year after year, with some small variations up and down, but with very little prospect of any radical change. It is not a subject for one day's discussion on the Ministry of Labour vote or on the motion for adjournment. It ought to receive daily consideration. People ought to be dealing with this thing insistently and consistently, looking at it from all its possible aspects, making it the real test of success in Government whether this problem is or is not being solved.

At the present time—I say this without any kind of party feeling—the problem is not only not being solved, but very little is being done. The whole tendency of the legislation recently introduced into the House of Commons—and I say this with a great sense of responsibility as one of the industrial leaders in this country—is much more likely to produce more unemployment than to diminish it, and it betrays how far away those concerned are from the actual concrete realities under which we live when we find that their minds are so much occupied with problems which, while admirable in themselves, seem to be quite out of harmony and keeping with the necessities of the moment.

There is another factor which is often overlooked. We have an annual increase in population in this country of about 300,000. The annual increase in numbers thrown into the labour market in the insured industries alone is 120,000. We have had, for two or three years, going up or coming down by a few thousands, roughly one and a quarter million of men and women unemployed, and we cannot absorb the annual increase in the industrial population which is coming upon us, so that there is a tendency to the increase rather than the diminution of this total number. The only bright spot in a rather lugubrious picture is that since the war the population of this country has increased by four millions, and even with our high unemployment figures the country is employing something like three million more people than before the war. This shows that in spite of our difficulties our industries have increased and developed since the war, but the rate of progress is insufficient to deal with the increasing population and is insufficient in the ratio which we require to re-establish our position.

I have endeavoured to summarise—and I have done it very shortly, because I did not wish to exhaust your patience—the amount of existing unemployment, some of its causes, and the position in which we find ourselves. To what conclusion are you inevitably driven ? You are driven to the conclusion that it is only by increasing the volume of our trade and stimulating production that greater employment will result, not merely in any one industry, but in industry generally. One of the chief things which is keeping apart the seller and the buyer to-day is the cost of production. If cost of production can be reduced, if the seller's price can be brought closer to the purchaser's capacity, a greater amount of business will result. The question is : Can a practical scheme be devised by which this gap can be in any way bridged ?

There are many methods which in time will operate and are bound to operate to help to bridge this gap. I do not want anyone to imagine that

I am not fully aware or fully cognisant of the many factors which are necessary to the permanent rehabilitation of British industry. I will merely mention a few: new and improved methods of output, organisation of administration and management, revision of our system of taxation, both local and national, the importance of research and invention, reduction of what I might call our strangling transport charges, greater and fuller co-partnership between all those engaged in industry—all these that I have mentioned are right and necessary factors for the improvement of our industrial condition. They will take time, they can only operate slowly, and they can operate better in times of less than in times of greater depression. Hope is an immense factor in the psychology of business. Confidence is of the utmost value to encourage people in the heavy work and outlay of business improvement and reorganisation. It is, therefore, of essential importance that you should stimulate in all these necessary directions as far as possible by inducing that psychological atmosphere in which people will work, not as those who labour under a heavy weight of despair, but with a buoyant feeling of optimism and confidence.

It is this which really is the one valid excuse to be brought forward for Government interference, a thing which I myself deprecate if it can ever be avoided, and Government assistance to industry in the condition in which it now finds itself. We are spending year by year—sometimes by methods which are seen, and at other times by methods which are not seen—vast sums on subsidising people to do nothing. Since the Armistice, in unemployment insurance, in poor-law relief, and in other methods, we have spent nearly £300 million, not to obtain work, but to subsidise idleness. When you put it into cold figures you wonder that any nation is prepared to go on spending something like £100 million a year for no other purpose than keeping people out of work, with the spectacle before it of a deteriorating industrial population, of a generation growing up which has never known work, and which, if the situation continues much longer, will never be capable of work, of industries falling into desuetude, of craftsmen losing their skill. When prosperity returns those who have been so long battered by fortune and have lost hope, who have tramped the streets for months, who have become used to living on the dole or on poor-law relief, whose independence has been sapped—do you think these people will come back to full industrial efficiency just because the nation wants them to, when nothing has been done for them all this time? That is a thing which every employer of labour knows. You have got to pay at least as much attention to the worker as to the boiler plant. Yet people do not seem to have realised yet the psychology of that most vital part of the industrial machine—the industrial worker—nor that for the help and assistance which he is to industry, he is entitled to have as much consideration paid to him and the problem of maintaining him as the maintenance of the plant which everyone treats as a matter of course.

This is to my mind a vital and insistent problem which demands and is entitled to have an answer. Is it possible to find work for the workless, not in expensive relief works, not in turning the skilled man into an unskilled man, but by giving the man work in his own trade, where his economic efficiency would be highest? Is it possible to stop the continuing deterioration which enforced idleness brings about, and to give employment to that large army of young persons who since the war have been trained to no work at all? It is by the answers you give to these questions that any scheme you put forward has to be judged. The vitally important question is not whether this scheme is a breach of economic law, but whether we can afford to sit by as we are doing now and do nothing. If you agree that you cannot afford to sit by, then all the other points become secondary and relatively unimportant. If you take the view that we can afford to sit by, that our fears are exaggerated, that the consequences which I and others see in our present position are not so serious as we think, that we can afford to "wait till the clouds roll by," that provision will be forthcoming somehow even as the manna was dispensed from heaven, then you are entitled to build up those destructive hypotheses, those criticisms, those negativisms which are always the answer of the do-nothings to those who have produced a scheme of reform, and have always been the answer in all the history of the world.

No one—certainly not myself—would care or endeavour to put forward any scheme of the character which I am putting forward unless he had been convinced of the utmost necessity of doing so at the moment. The creator is generally aware of the defects of his creation, the parent of the defects of his child, and no one is more painfully aware than I am of some of the difficulties and complications which may arise.

Before I pass on to the explanation of the details of the scheme which I have worked out, I should like to say a few words about what we have already succeeded in doing so far in order to assist trade and to provide employment. We have the Trade Facilities Acts, 1921-24, one of the products of the Cabinet Committee, to which I have referred, in which the Government has guaranteed up to April 28th, 1925, something like £55,500,000. This is a considerable sum, a sum not to be despised, but relatively small when compared with the large volume of capital which necessarily flows into industries in this and other countries where it can be used. We have then export credits under the Overseas Trade Acts. The total advances of credits up to March 28th were £14,750,000. Anyone who knows the volume of credits given in the City of London will not consider that a brilliant result. Then we have the unemployment grants of assistance to local authorities, under which sums have been paid out from year to year to assist the authorities in their wages bill. The total cost of the schemes is somewhere in the neighbourhood of £22,000,000. Public utility companies have undertaken schemes costing £2,000,000, making a total under this head of £24,000,000. We have in total, as a matter of fact, for the last three years, under various alleviations, £69,000,000 under trade facilities and export credits, and £13,000,000 in other directions, including emigration, free passages, and other relief of the unemployed. The total is fairly considerable, but it is a very small total indeed for the provision of work in comparison with the total which is spent in supporting people who are out of work. This year, curiously enough, the estimate for the relief of unemployment so far as the Government is concerned is on a smaller scale than for a number of years. Why this is so I cannot understand, because the need seems to me as urgent as it has ever been.

I pointed out in the earlier part of my lecture that we have an increasing population and an increasing difficulty of finding work for them. It has been stated more than once that this country has depended in the past to a very large extent on the fact that countries which grew food were prepared to exchange their food and raw materials for our manufactured goods. If those conditions no longer hold good in the economic world two things must result: (1) We cannot support the same population unless it provides more food in this country; (2) people not able to support themselves in this country must go to other countries where they can grow the food to support themselves. Therefore emigration becomes one of the important factors in dealing with the unemployment problem. The Overseas Settlement Act was started in order, for the first time, to work with our Dominions for the development of emigration. Up to now, I am sorry to say, the Act has not done anything like as much as the authors of it expected. Schemes are being worked out which, I hope, will proceed on a more rapid and larger scale. But I would like to throw out the suggestion whether it would not be for the benefit of this country if those who have subscribed for years to unemployment benefit become entitled in some form or other to commute their benefit for a period of time in return for assistance to enable them to emigrate. It might be costly to begin with. One of the difficulties is that the emigrant wants capital. But would it pay us possibly in the long run for those out of work to go out to our own Dominions and help to people the vast areas of our own Empire, assisted in the manner that I have suggested? It is a point very well worth following up and investigating.

Having made, shortly, these preliminary statements, I will now come to the scheme which I have placed before the country to deal more immediately with the stimulation of industry and the replacement of the workless in their work. The object of the scheme is to obtain work for those who are now receiving out-of-work benefit (and for this purpose I am treating covenanted and uncovenanted benefit on the same basis):—

(1) The unemployed worker must be entitled voluntarily to surrender his unemployment benefit of 23s. a week in return for definite work at full trade union district rate of wages for a definite job for a definite period. When

the scheme enters into operation every labour exchange would be instructed to open a register of those unemployed prepared to undertake work on this basis.

(2) The recipient of the advantage of obtaining a wage reduction or subsidy would be the employer, who could utilise this labour. It is obvious that to achieve a diminution in the number of unemployed and to prevent a mere substitution of those already engaged in industry by those out of work, measures must be taken by which only employees in excess of the establishment of any given firm at a given time can be eligible to be engaged under the proposed subsidy.

(3) Employers prepared to engage additional workers under the scheme would apply to a committee, representing the employers, the trade unions, and the State, in proportion to their contribution to the unemployment fund. The employers' panel would adjust matters affecting employers alone; the trades union panel would adjust matters relating to those about to be employed, and the whole committee matters affecting the various panels and general points at issue. The committee would decide whether the granting of the application would or would not increase the total volume of trade and, therefore, of employment.

(4) Employers, after having received the sanction of the committee, would notify the employment exchanges of the number of new workers they would take into employment on full time at full trades union rates for a definite period (say, for example, six months) in excess of the average number fully employed by them during the twelve months preceding the "appointed day."

(5) The "appointed day" would be a date defined in the legislation which would have to be passed to make this scheme effective. The date would presumably have to be the day upon which the adoption of the scheme by the Government was first made public.

(6) In respect of 75 per cent. of the workers actually engaged as the result of the above notification, the employer would be entitled to receive the unemployment benefit of 23*s*. a week due to those workers from the labour exchange through which he engages the men.

(7) The cards of all workers who had been continuously unemployed for three out of the six months preceding the "appointed day" and who had notified the exchange of their willingness to come under the scheme would be stamped by the employment exchange in order to ensure that these men would be the first to be employed under the new scheme.

(8) Any firm set up after the "appointed day," with the exception of schemes for the employment of unemployed ex-service men (which would receive special consideration), would receive the 75 per cent. of the unemployment benefit only in respect of half the total number of men employed. Moreover, the firm would have to prove commitments into which it had entered before the "appointed day" and would have to start operation within three

months of the scheme coming into effect. Such commitments should preferably be proved before the special unemployment committee defined below.

(9) So that the scheme might end automatically when the greatest need for it had been met, the number of men and women for whom the employer would receive the 23*s.* per week would have to be reduced at the end of a six months' period after the "appointed day," and subsequently at the end of every three months' period, by 2 per cent. more than the percentage reduction in unemployment in their industry, as ascertained by the Ministry of Labour since the date when the scheme began to operate. For the purpose of this calculation, the total number employed under the scheme would be regarded as employed.

(10) The scheme would end automatically when the reduction to normality in the unemployment figures is reached, and this figure should be stated in the legislation necessary to put the scheme into effect.

(11) The scheme would apply to men, women and youths in all insured industries in which the unemployment figures were above normality.

(12) Employers, for the purpose of the scheme, would include all industrial companies, local authorities and public utility undertakings—that is to say, every class of employers of labour.

I stress the fact that the surrender of benefit by the unemployed worker must be voluntary. You could not possibly, ethically or legally, deprive him of such a right unless he was ready to surrender it. On the other hand, to safeguard his wage, and also in view of what I may call in-and-outness, he must have a definite job for a definite period. I believe a large number of men will be delighted, if they are given the chance, to earn again a reasonable wage in their own factories. The employer who could utilise the labour would get the advantage of the subsidy. One of the difficulties to be guarded against, a thing which seriously wrecked the schemes tried in this country after the Napoleonic wars, is represented by the employer who might discharge some of his men in ordinary employment and obtain this subsidised labour in their place. To safeguard against that I have provided that it is only for excess labour that this subsidy will be available. For this purpose it will be necessary to have a datum line which can be fixed on a certain day for the number of people employed in the factory, and only in respect to any excess above that number would the scheme operate at all. To the firm employing the additional workers, I would give the advantage, not of the full benefit—the whole 23*s.*—but 75 per cent. thereof. The other 25 per cent. would go immediately to relieve the unemployment insurance fund. In that way there would be a direct benefit to the taxpayer, as well as to the workman and the employer, for every man who was taken on. The object of the committee already described would be to decide whether or not the granting of an application for additional workers would increase the total volume of trade, and, therefore, of employment. Unless a greater volume of trade was actually forthcoming, the scheme would not be fulfilling any useful purpose; indeed, it would have a harmful purpose, because to subsidise business is obviously uneconomic. One of the important points is how this scheme is to come to an end. The difficulty of all schemes of the kind is to discover some automatic means of closure. I have endeavoured to do so in several ways, and I have varied the method which I first published in the pamphlet I have circulated, because on going into the matter further it seemed to me that the method I have now adopted (as set out in paragraphs (9) and (10) of the scheme as given above) was more likely to answer the purpose.

Those are the bare bones of the scheme, and I will endeavour to fill out some of the more important points only in the remarks I now have to make to you.

The first point concerns the functions of the committee which I have already mentioned. These committees could either be trade committees in their district, with a co-ordinating national committee, or local committees representing various industries. They would be rather on the lines of the local unemployment committees which exist to-day. I have already outlined to you the procedure they would follow. Their work would be responsible. They would have to satisfy themselves that the worker applied for would not merely mean transference of work from firm A to firm B. The employer would have to convince the committee that the granting of his application would provide new business which otherwise would not come into the country at all or would not be executed. This would be the essential and irrevocable criterion. The criticism which has been made of my scheme, criticism which has been repeated, I am sorry to say, by the Minister of Labour, seems to overlook certain important points. The argument always seems to be based on a series of fallacies. The main fallacy involved is the fallacy of looking on industry as a static instead of a dynamic organisation. It is always assumed that if A and B are competing, and B gets an order, A loses it. That would be quite true if the volume of business in the world was definite and fixed. But the fact is, there is not x business in the world, there is x plus y, and y is the unknown factor. It is to obtain this unknown y that my scheme is framed. I cannot tell you the dimensions of y, all I know is that there is y. Therefore, when the Ministry of Labour and others say that my scheme is useless and will achieve more harm than good, simply for the reason that it will take work from a firm which has got it and give it to another which has not, my answer is that that is by no means true, that if the volume of trade can be increased, firm B, which to-day is working with half its complement of men, can perfectly well be put on a complete complement of men without firm A suffering in any way. The objection is not true in practice, it is true only in hypothesis. Take one of the main industries, such as shipbuilding. I believe examination would show that there is practically no firm, however eminent and capable, which to-day in the depressed industries is not working below its 100 per cent. capacity—and very considerably below.

But these inequalities in reality would not exist. I cannot understand the contradiction in people's minds when they one day make the welkin ring with a cry because a Dutchman or a German has got an order for a ship or a Belgian an order for a railway tyre, and the next day, when you produce a scheme which will enable some of them to employ more men, turn it down on the ground that it would help one firm at the injury of another. It is for the national prosperity that somebody in this country should get an order, that somebody should get employed, that something should get started. I feel amazed at the main line of the argument and discussion which I have been compelled to carry on with critics of this scheme for a considerable time. It is apparently on this ground finally that the Minister of Labour in the present Government has told the country that my scheme cannot be adopted. I contend—and I hope I have convinced the members of the Government—that the machinery of the committees which my scheme would create to safeguard these points would result in an efficient guardianship against inequality and waste of public money. I do not say that on no occasion, in no way, or in no manner, somebody would feel aggrieved, but I would venture to say this, that there is no scheme of amelioration in existence to-day which does not operate inequitably as between different industries and different firms. There are some industries in which unemployment is almost non-existent, yet they have to bear the heavy burden of the general load. In national health insurance there are numbers of people whose health is never affected, and yet they have to contribute. It is no answer to the scheme I am putting forward to say that inequalities might occur, and that, therefore, one must sit still and do nothing. There is, of course, not an unlimited and absolute universality to which my scheme can be applied. From its very nature, and from what I have said already, it will be understood that it lends itself more readily to what I might call solid business of a big character than it does to business of a more fluid kind. It is obviously easier in the case of ships or big engineering work—bridges and things of that kind—for the employer both to undertake definitely to engage men for a number of months at definite rates of wages, and also for him to demonstrate that his work is work which otherwise would not be obtained. But it is just in the industries which now are most depressed that the scheme would be most operative.

I would like to say a word about the other industries. When I had the honour of explaining the scheme to representatives of industry I was gratified to find the ready response which came from those to whom I frankly said that for them probably there would be no advantage in the scheme at all. What they felt was that in our present condition of industry it was not for people to look in a selfish, narrow way after their own industries, and that any scheme—even if without benefit to themselves, they contributed, as they would do, to the unemployment fund—which brought about the general benefit, was a scheme they should support. It is really in this attitude that this scheme has to be surveyed. It is in this way that it must be treated. It is impossible, without experience of the thing in practice, to meet every possible difficulty and objection. But I would prophesy this, that most of the difficulties which are raised now in anticipation would probably never occur, and many difficulties which no one sees now would make their appearance. That is always the case in social legislation. You can only hammer this thing out on the anvil of practice. It is only when you have the thing going—and you can go cautiously, slowly, if you like, I am by no means a rash person—that you will begin to see whether or not the difficulties anticipated do arise, and, if so, how you are going to surmount them. We are not entirely deficient in adaptability or practical genius in this country. The scheme to my mind presents no practical difficulties which are not capable of being overcome. I have endeavoured to foresee and forestall difficulties, to meet criticisms, and to make changes where criticism seemed to justify them. But there comes a point when you cannot proceed on these lines any further. In every discussion which I have attended, some individual will raise some new hare, and if you course them all, the pack finally gets so split up that no hare at all is caught. And if you go zigzag, and take your course down every byway, you will never, in a complex community like ours, carry through any scheme.

I believe that this scheme will achieve a great part of its object. The worst thing it could do would be to fail. The worst thing that could happen would be that it became necessary to repeal it. The worst possible event would be that no more people would be employed than are employed now; it could not mean that less people would be employed. When you have deterioration of human material and the attendant misery, when you have an apparent inability to pull ourselves up out of the slough of despond, on the one hand, and, on the other hand, when you have a scheme which affords a glimmer of hope of improved conditions, why should you not, at any rate, give it a trial? See what it can do, and if it fails—as I do not believe it would fail—you would be in no worse position than you are to-day. But if it succeeds you might be in a very much better position. Such a scheme would help to justify our present order of society, which to-day is being attacked daily, nightly, weekly, by those who claim that it is a failure, and that we have not the capacity nor the ability nor the desire to alleviate the present conditions. I say if you succeeded you would have done, to my mind, a fundamental thing—not merely in an economic sense, but in a much wider sense—to re-establish the confidence of the toiling millions of this country, not in those who want to lead them on the road of revolution, but in those who believe our existing social structure is capable of solving the difficulties and the miseries of the situation.

DISCUSSION.

The Chairman (Sir Robert Hadfield) said that the Society had listened with intense interest to a masterly address. There were a number of eminent authorities present, and he hoped they would take part in the discussion.

THE RIGHT HON. SIR HENRY NORMAN, Bt., welcomed the opportunity of expressing his thanks to Sir Alfred Mond for a very interesting and instructive and, if he might use the term, a very genuine address. The gravity of the problem was unfortunately a commonplace, and it was rendered in some respects more grave by reason of the fact that those who had the ear of the public were not always those who had the knowledge of the conditions necessary for forming a just estimate of the present and of the future. Many of the politicians who had the ear of the public had not the knowledge—with all respect to them be it said—whereas business men who really knew the state of things very often had not the ear of the public. Sir Alfred Mond, fortunately, combined the two things. He had an intimate personal knowledge and experience of great business, and he was listened to in politics. The speaker would refrain from applying the line, "The shallow murmur but the deep are dumb," but in Sir Alfred Mond they had a man who combined deep knowledge of the problem with the faculty of impressing his fellows. He had made a remarkable contribution to this great problem. The speaker had studied the scheme as carefully as he could. He saw, as they must all see, a number of objections to it, but he had never seen any great public scheme which was without its serious objections. It might be that in some respects Sir Alfred had made mistakes, but a great man said that those who never made mistakes never made anything, and the situation was so serious that the attempt should be made in every possible direction, no matter how new or uncertain, provided it could be seen that no gravely injurious consequences could ensue. We were afraid, in this country, of new ideas—the idea, for instance, that the consumption of raw coal must cease before long, or that the question of birth control was almost more important to us than the League of Nations. Novel ideas and conceptions ought to be faced with courage. Sir Alfred Mond's scheme was a novel one; even if it were proved not to fulfil all the hopes and expectations that he and others cherished, it would have no grave injurious consequences, and if, on the other hand, it was sound in conception and in execution—and he did not think any man was more capable of judging the effect upon industry than Sir Alfred Mond—then its benefit might be so great as to be almost incalculable.

MR. J. A. SEDDON, C.H., said that from the first moment when he read what Sir Alfred Mond had published on this question he felt that here was a man with vision and courage and one not afraid of putting forward what he thought to be a contribution towards the solution of this problem, which, in the speaker's judgment, was the greatest problem of the present moment. In 1914 when the war broke out many politicians and statesmen had to scrap all their preconceived ideas, economic and otherwise, and, with very few exceptions, they did it right nobly to save the country from a grave disaster. He ventured to say from very close association with the unemployed workers of this country that the menacing danger from unemployment was as great to-day as was that from invasion during 1914. During the last twelve months or so he had laid himself out through various channels and agencies to get closely in touch with the unemployed worker. It was possible almost to classify the various men to whom the dole was a godsend. There were some who had never worked before and never wanted to work. There was the adolescent who had never learned any trade whatever; his condition was tragic. But he wanted to point out more particularly the effects of unemployment on the great mass of working men who had solid British commonsense and a keen desire to work if they were given opportunity. He had discussed the problem with scores, he might say, hundreds of them. Within three months men who had had courage began to have their doubts; within six months their hopes had gone, and they were fit material for revolution. Their attitude was one of hopelessness. They were apt to say that things could not be worse, even under revolution, than in their present state. When the *morale* of the best type of working-men was destroyed the high road to national decay lay open. Therefore, the speaker welcomed Sir Alfred Mond's determination to find a way out. When the Minister of Labour was echoing what to the speaker's mind were superficial objections it was time for the man in the street and the business man to say what was said many years ago by a well-known statesman, "A plague on your politicians!" It was time to exercise that common-sense which was claimed as a characteristic of the race. He believed that Sir Alfred Mond's scheme was along the lines of common sense. He knew that many of the men who gathered at the street corner were snatching at this new hope as a drowning man clutched at a straw. They said that at last somebody who was a politician and who also understood business had declared that there was a way whereby those who were willing to work should not be condemned to the degradation of drawing the dole or poor-law relief. He himself was ready to go to the street-corner and commend the scheme.

Mr. Robert H. Thorburn asked whether the scheme could not be carried further so as to strengthen the formula of x plus y. The scheme would be objected to to-day on the ground that y represented nothing. There was a way of strengthening y. He asked the audience to have regard to the deficiency of 25 per cent. in the export trade. He quoted from three members of Parliament with whose opinions on other matters he was not in agreement—namely, Mr. Wheatley, Mr. Tom Johnston, and Dr. Haden Guest —suggesting that imports should be prohibited of articles which this country was capable of producing in the full measure of the demand. He had devoted a good deal of time to the study of this and similar problems, and had made an original investigation into so-called "invisible exports." He had examined Board of Trade methods and found them absolutely rotten and defective, and the principal explanation of this situation was over-importation—the importation of so many things for which there was no corresponding export. There was colossal over-importation going on in this country. Why should not all imports of motor-cars be prevented instead of having put upon them a duty of 33 per cent.?

Sir Frank Baines, C.V.O., C.B.E., said that he had had the privilege of serving under Sir Alfred Mond, and in that capacity he had had wonderful evidence of his power of synthesis, as indeed had been shown again in the review of the situation he had placed before the Society that evening. Sir Alfred Mond had stated admirably the broad facts of the situation, he had suggested where the disease mainly lay, he had recognised that unemployment was the Achilles heel of modern civilisation. But Sir Alfred approached the subject with caution—some might even think with too much caution, and might wish that he would throw a little of that political caution to the winds. But he had been extraordinarily suggestive. He was the one politician whose general reputation had increased quite apart from whether he was in or out of office. One of his distinctive features was his power to think aloud. When the speaker was serving under him he repeatedly dropped ideas, so to speak, by the way—as, for instance, that the enemy should be made to pay the indemnity, not in the mark nor in gold, but in goods which we ourselves could not produce; and, again, that this country seemed to have its eye magnetically held by that great country on the other side of the Atlantic to the detriment of every other field of vision. It had been a great pleasure again that evening to listen to his masterly synthesis and exposition.

A **Member of the Audience** said that he believed every applicant for benefit at the Employment Exchanges had to prove that he or she was genuinely seeking work. He suggested, therefore, that if the committees did their duty there ought to be no slackers in the country generally.

The Chairman said that the Society would wish Sir Alfred Mond godspeed in this excellent work, and his paper would be appreciated not only by those present that evening, but by a very large circle of readers.

Sir Alfred Mond said that he would not inflict another speech on the audience. He only wanted to say how much obliged he was to Sir Robert Hadfield and others who had encouraged him to go on with his work. It would take him too far to enter the whole field of economics by discussing the question of the total prohibition of imports; that would be to keep the audience there all the evening.

Sir Robert Hadfield had prepared certain remarks to make on introducing Sir Alfred Mond, but in view of the desirability of giving the lecturer as much time as possible for the exposition of his scheme, he did not deliver them. What he had intended to say was as follows:

In his recent proposals to use unemployment insurance funds to subsidise unemployment Sir Alfred Mond has made a bold bid to cope with this most serious question. Whatever may be the final result with regard to the adoption of his plans, at any rate he has done great service to our country in stirring up full consideration of this vital question of the day.

Unemployment is the subject which has baffled the minds of the wisest of the wise. The finest intellects amongst our politicians, year after year, decade after decade, in fact one might add generation after generation, have tried solutions, but with little success.

Sir Alfred, in a recent speech at the meeting of Messrs. Brunner, Mond & Company, pointed out that we had reached an economical crisis in British industry, perhaps one quite as serious as the war crisis, and that there were many industries tottering towards disaster. I believe that most of those present this evening will agree that this is perilously near the truth. The present excessively severe depression is undoubtedly one resulting from the aftermath of the gigantic world cataclysm known as the Great War.

That the times must indeed be bad is shown by a statement made by the Prime Minister only a few days ago, in which he said that not only was his income about one-fifth of what it was a few years ago, but that for the last three years he had been doing what he never had done before in his life, namely, living on his capital and borrowing.

We know that during the war there was no unemployment, everybody was busy, each one having his work set out and allocated, and each did this to the best of his ability. Now, alas, everything seems disorganised and chaotic. Most Englishmen and Englishwomen deplore the dole system, the leaders and chief workers quite as much as the employer, but some such plan could hardly be avoided immediately after the war with all its attendant upset.

Speaking personally, when recently walking round our own works at Sheffield, in which city there are, alas, still 27,000 men wanting employment, it is difficult to imagine that these works were occupied during the war by some 15,000 busy workers; yet now we can hardly support one-third of this number. The will to work is there, but want of work makes it impossible to give employment. This is the fault neither of master nor man. Everything during the war, as regards production, was a great success, but during peace everything seems to be a failure. The same willing workers are ready to work; the same chiefs and heads of large firms are there to direct operations; but, unfortunately, there is little or nothing to direct.

Capital says, "Work more and more will be paid;" Labour at present says, "Work less and get more money," which is an impossibility, because it is like trying to make water run uphill. Probably both sides are wrong. As regards Capital, there is not the work in existence, and as regards Labour, surely it is a wrong principle to go against one of Nature's laws, proposing to do less work and yet obtain higher values in return.

The following information with regard to the unemployment position in this country may be useful, and I thought might be added to the discussion this evening. Some portions of these notes are prepared from information received direct from our works in Sheffield, through the joint Managing Director there, Mr. P. B. Brown:—

The following is roughly the present position of unemployment:—

Unemployed.	April, 1925.	Last week in April 1924.	April 1921.
National	1,250,853	1,052,472	1,854,059
Sheffield	24,356	23,019	59,196

During the last week in April, 1925, the large sum of nearly £907,000 was paid out in unemployment pay through all Exchanges, of which £18,100 was paid through the Sheffield Exchange. The National Unemployment Insurance Fund is now overdrawn to the extent of about seven million pounds, indicating that a crisis, such as the one through which we are now passing, was never contemplated by the actuaries who went through the figures whilst the Insurance Bill was passing through the House of Commons.

In contradistinction to the foregoing, the position of the Health Insurance Act may be mentioned, under which the Government seems to have been able to accumulate a surplus of thirty million pounds—as shown by a short article which appeared in the *Sheffield Daily Telegraph* of May 19th, 1925, to the following effect:

"The Sheffield Joint Hospitals Council is to take an important part in the deliberations of the Royal Commission which is sitting to consider how the National Health Insurance Fund can best be used in the interests of the community. The Commission has invited the Council to give evidence on Thursday, May 28th. A deputation, headed by Sir Henry Hadow, the Vice-Chancellor of the University, has promised to attend, and will put forward a claim on behalf of the Voluntary Hospitals for a portion of the surplus which accumulated from 1919 to 1923.

After allowing for every liability there is likely to be a surplus of fully thirty million pounds for distribution in benefits to insured persons in this country. This will allow for no less than £250,000 for division amongst insured persons in Sheffield. The voluntary hospitals, which are suffering from serious financial embarrassment, maintain that a percentage of this sum should be allocated to them. One reason why this claim is made is because the hospitals are providing in-patient treatment for a very large number of insured persons who are already contributing to the National Health Medical Service."

In Sheffield I know that employers have done and do their utmost to keep as large a number of employees on their books as possible. In most of the large works short time is now being worked for the express purpose of finding sufficient employment for the men to enable them to be kept off the list of those who obtain either unemployment pay from the Government or doles from the Guardians.

Public sentiment, as voiced in the Press, by Municipalities, by the Board of Guardians, and by the Trade Unions, is unanimous in recommending that this endeavour to keep as many men as possible in employment should be continued. Many employers, like my own firm, are doing their utmost in this direction, when, as a matter of fact, if we thought only of our own selfish interests, it would be much more economical to work a full week with a reduced number of men.

Unfortunately, the proposal of the present Chancellor of the Exchequer to levy fourpence per man per week from the employer, and a similar amount from each workman, will tend to go a long way towards preventing employers continuing their endeavours in the direction above indicated.

Just let us take the present position. Under the Unemployment Act, the employer pays tenpence and the workmen ninepence (total 1s. 7d.) per week, quite irrespective of the number of days a man may work in any week. Under the Health Insurance, the contributions are fivepence per week from the employer and fivepence per week from the workman, and that amount also has to be paid whether a man works one, two, three, or six days in the week.

The new contributory scheme would add another fourpence from the employer and fourpence from the workman, which, as will be seen, is an extremely heavy load, especially when three days only per week are being worked. It is twice as heavy as if the men were working six days. This is a most important point.

All these charges go to increase our costs of production, and make it the more difficult to compete with Continental nations. The cumulative effect on Industry is very great, as they apply not only to those who get out from the earth the various raw materials required, such as coal, and ironstone, but to all other works engaged in the intermediate processes, including transport and others.

At the moment I do not recollect having seen an estimate of the total cumulative effect of the Unemployment and Health Insurance Acts, say on a complete engine, machine tool, or ship, but the total extra cost must be very great. Whilst few to-day would advocate the cancellation of such humanitarian measures as Old Age Pensions, Health and Unemployment Insurance, the time has arrived when very serious consideration should be given as to whether such burdens should not be taken by the nation as a whole, rather than by the direct employers of labour, upon whom most of the burden is saddled.

NOTES ON BOOKS.

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HELMHOLTZ'S TREATISE ON PHYSIOLOGICAL OPTICS. Translated from the Third German Edition. Edited by James P. C. Southall. Volume I. Published by the Optical Society of America; also George Banta Publishing Company, Menasha, Wisconsin, U.S.A.

Many difficulties had to be overcome before the long-delayed English version of this great work could be satisfactorily produced, and the honours seem to rest wholly with those on the other side of the Atlantic, while the immediate gain is to all those who use the English language.

Professor James P. C. Southall, who occupies the Chair of Physics in the Columbia University, managed to gather around himself a little group of enthusiasts whose aim was to give a true rendering in English of the real Helmholtz as he thought, spoke, wrote and illustrated, no mean task considering the colloquial but highly technical style of the illustrious pioneer, and also the fact that modes of expression and thought in physics have changed considerably since Helmholtz wrote the matter for his first edition of 1866. After a very thorough consideration of all the circumstances, which are sufficiently explained in the mass of prefatory matter, it was deemed expedient to make the present translation from the posthumous third German edition, which appeared in three volumes, 1910, 1911 and 1912 (see pp. X-XIV of prefatory matter), which edition reverts to the first and original text of Helmholtz as it appeared in 1856, 1860 and 1866. Thus, the second edition, which appeared in 1885 is left out of count altogether, and we may assume that it was from this second edition that it was proposed to make an English translation about twenty-five years ago a proposal which appears to have fallen through because Professor Arthur König and the heirs of Helmholtz objected to it as being unfair to his memory. (See letter in *Nature*, March 21st, 1925, also compare p. XII of the work now under notice.)

The great work of Helmholtz has been so well known in its German form for nearly three-quarters of a century that no detailed description is required, but we may remark that in respect to clearness, logical form and sequence, with pertinent illustration by instrumental means easy to obtain and use, the work of Helmholtz is comparable with Faraday's Lectures on a candle.

The text and apt illustrations of Helmholtz as now presented to the English reader are accompanied by notes, references and such new matter as is now desirable to supplement that original text which is translated but otherwise untouched; also we may remind individuals and institutions that the first volume now before us consisting of XXI + 482 small folio pages, with portrait frontispiece and 149 illustrations in the text, should be secured promptly, and that Vol. II is published and Vol. III nearly ready.

MONUMENTAL BRASSES OF BERKSHIRE. Illustrated and described by H. T. Morley. Reading: Electric Press. £1 1s.

Mr. Morley set himself no light task when he endeavoured to form a complete list (with illustrations of the effigies) of the monumental brasses laid down before the 18th century and still remaining in Berkshire. The county is very rich in these interesting memorials: what its wealth would have been had not the vandalism of the past and the carelessness of the custodians played havoc amongst them, one can but guess. Churchwardens found them useful, says Mr. P. H. Ditchfield in his foreword, and sold the metal in order to defray reparation works in the churches. "Restorers" have also been guilty, taking up the brasses and forgetting to replace them. Of the 50,000 brasses which, it is estimated, existed in England in the Middle Ages, only a tenth remain to-day.

The volume contains 160 illustrations, and the author's descriptions deal with the costumes of the ladies, vestments of the ecclesiastics, armour of the soldiers, heraldic emblems, etc. Nearly all the illustrations are made from rubbings taken by Mr. Morley himself during the last thirty years. The work, which is admirably printed, is a valuable contribution to the antiquarian lore of Berkshire.

MODERN INORGANIC CHEMISTRY. By J. W. Mellor, D.Sc. New Edition. London: Longmans, Green & Co. 12*s*. 6*d*. net.

Previous editions of this book have occupied a well-merited place on the shelves of most of those engaged in the teaching of chemistry, and no doubt many replaced the old by the new on being informed by the publishers that an entire revision had been undertaken, the number of pages being increased from 930 to 1,123, and the price nevertheless remaining at its former astonishingly low figure. Thus it was that the present writer, at all events, was in the happy position of having attained some familiarity with the new edition before being called upon to attempt a review.

As many know, although the book is mainly devoted to systematic inorganic chemistry, the physical aspect of the subject is also developed in a series of sections inserted at appropriate points, illustrating the physical questions as they arise. With regard to the inorganic portion, one need only say that there is general agreement as to its excellence. One looked, naturally, in a revised edition for the correction of small errors, and was glad to observe the deletion of the statement that *both* diethyl sulphites furnish sulphurous acid when treated with water. In one instance, namely that of the dimorphism of potassium nitrate, p. 612, the correction has been incomplete. In the 1912 edition the relative stabilities of the rhombic and rhombohedral forms were transposed, and the error has been allowed to remain in one sentence, so that there is a contradiction in the text as it now stands.

There are still some errors in the spelling of proper names. For English writers to refer to Jacobson as " Jacobsen " (p. 511) is curiously common, but one took " Kohlrauch " to be a printer's error until finding this form repeated on another page and also in the index.

Turning from the inorganic to the physical side of the book, it is impossible to avoid the comment that the latter is not on the same plane of excellence as the former. Much might be said on the broad question of whether it is useful to attempt physico-chemical teaching in dispersed paragraphs in an inorganic text-book. Certainly many competent teachers could be found to commend the method, but it can hardly be denied that such condensed presentation as is here attempted makes very great demands on the student's capabilities. Moreover, it seems extraordinarily difficult to treat the subject on these lines without being led by the need for brevity into actual unsoundness, and the reviewer noted many passages which seemed to him incapable of sustaining a critical scrutiny.

What, for example, is the student to make of the section appearing on p. 363 ? At the head is set a quotation : " Those bodies only are electrolytic which are composed of a conductor and a non-conductor.—W. A. Miller " ; while we read later in the section that : " Some fused salts—e.g., silver chloride—conduct electrolytically . . . ." But what is much worse is that the section begins by saying : " The more care taken in the purification of water, the less will it conduct electricity, and consequently it is assumed that pure water is a non-conductor, in spite of the fact that perfectly non-conducting water has not yet been made." On reading this, it will occur to any intelligent student that he has heard of the ionization of water, and he will probably look in the index for a reference to this subject. Baffled here, he may possibly not persevere sufficiently to discover how the subject of salt hydrolysis is treated ; but if he does so far inquire, he will find, on p. 538, statements as to the conductivity of water definitely contradicting the one last quoted.

Again, one cannot really be satisfied with the definition of Phase Rule components, p. 195 : " The components of a system are those substances which take part in the reaction, but which are not decomposed in the process." This is an ingenious rule, shorter and neater than those usually given, but it appears to the reviewer to be fallacious. It needs a most sympathetic stretching of the meaning of words to apply it, as is done on p. 197, to the steam—iron system, where the components are listed as iron, *oxygen* and hydrogen ; but a more definite test is provided by such systems as that of potassium cyanide—water. This, in virtue of the production and volatility of hydrocyanic acid, is one of three components, as may easily be seen by considering a system of the solid salt, ice, eutectic solution and vapour.

The composition of the solution here depends on the relative volumes of liquid and vapour; if the latter is enlarged, the quantity of hydrocyanic acid in it is increased, and in this way the concentration of potassium hydroxide in the solution can be given any desired excess over that of the hydrocyanic acid in the same phase. Thus four phases do not suffice to produce a non-variant system, and three components are, therefore, present; but no conceivable application of Dr. Mellor's rule could give this answer.

To use Boyle's Law, as is done on p. 150, in proving that a perfect gas would pass isothermally through a Joule-Thomson apparatus, is surely a *petitio principii*, because Boyle's Law, even for a perfect gas, does not hold *unless* the temperature is constant.

There seems to be a serious error in the phase equilibrium diagram for sulphur on p. 477, in that the stable melting-point curve for the rhombic variety is definitely drawn as a prolongation of the transition curve, instead of as a continuation of the metastable rhombic melting-point curve; and the accompanying text is so ambiguously worded that the uninformed student is given no reason to suspect an error.

There are many other instances in the physico-chemical portions of the book where similar complaints might, as it seems to the reviewer, be lodged; and his conclusion is that, while these portions provide many useful facts and interesting reflexions for those who have mastered the elementary theory of the subject, they also present numerous pitfalls to students, who *ex hypothesi* have not done so.

THE FATS. By J. B. Leathes, M.A., M.B., F.R.S., and H. S. Raper, C.B.E., M.B., Ch.B., D.Sc. Second Edition. London: Longmans, Green and Co. 12*s*. 6*d*. net.

This book, which is one of the well-known series of Monographs on Biochemistry, has been out of print for some considerable time, and its re-appearance in a new and enlarged edition will be welcomed by many. Roughly speaking, it is divisible into two fairly distinct parts, one purely chemical and the other physiological. The former, in three chapters, deals with the chemical and physical characteristics of the fats, the fatty acids, glycerine, and other alcohols which may take the place of glycerine; also with the extraction, identification and estimation of the various substances concerned. One wished it had been thought possible to devote a little more space to the recent work of McBain and his co-workers on soaps, though it must be admitted that it was not easy to select any particular paragraphs which might have been sacrificed for this purpose. The statement, on p. 5, that "In an absolute vacuum lauric acid boils at 89°, stearic acid at 128°," is surely a slip of the pen.

The second or physiological division has been greatly expanded in the present edition, and now occupies well over half the book. Beginning with an account of the existence of fats in nature and a discussion of the possible methods of their origin, it goes on to describe their digestion and absorption in the animal body, their occurrence in the blood stream on their way to the organs, their transfer to the organs and storage there, the discharge into the blood of such reserve fats to meet certain contingencies, both normal and pathological, and, lastly, the process of oxidation by means of which the fats perform one of their most essential functions, the provision of energy.

A final chapter of great interest is devoted to a consideration of the idea that "storage" is not quite the appropriate word for the state of the fats while contained in the organs, since their mere presence there serves purposes of the utmost importance to the organism. This last chapter is followed by an excellent bibliography, which should add appreciably to the value of the book.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

CHAIRMANSHIP OF COUNCIL.

On MONDAY, JULY 13th, at their first meeting in the new session, the Council elected SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S., Chairman for the ensuing year.

PRESENTATION OF THE SOCIETY'S ALBERT MEDAL TO LIEUT. COLONEL SIR DAVID PRAIN.

The Council of the Royal Society of Arts attended at Clarence House on July 10th, when Field-Marshal H.R.H. the Duke of Connaught, K.G., President of the Society, presented the Society's Albert Medal for 1925 to Lieut.-Colonel Sir David Prain, C.M.G., C.I.E., M.B., LL.D., F.R.S., " for the application of Botany to the development of the raw materials of the Empire."

The members of the Council present were :—Lord Askwith, K.C.B., K.C., D.C.L., Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I., Sir John H. Biles, K.C.I.E., LL.D., D.Sc., Captain Sir Acton Blake, K.C.M.G., K.C.V.O., Sir Robert Abbott Hadfield, Bt., D.Sc., F.R.S., Rear-Admiral James de Courcy Hamilton, M.V.O., Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., Colonel Sir A. Henry McMahon, G.C.M.G., G.C.V.O., K.C.I.E., C.S.I., Hon. Sir Charles A. Parsons, K.C.B., LL.D., D.Sc., F.R.S., Mr. Carmichael Thomas, and Sir Alfred Yarrow, Bt., F.R.S., M.Inst.C.E., with Mr. G. K. Menzies, M.A. (Secretary of the Society) and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

Lord Askwith presented Sir David Prain to the Duke of Connaught.

Lieut.-Colonel Sir Malcolm Murray, K.C.V.O., C.B., C.I.E., was in attendance on His Royal Highness.

DOMINIONS AND COLONIES SECTION.

An Extra Meeting will be held on MONDAY, JULY 27th, at 4.30 p.m., when PROFESSOR W. A. PARKS, Ph.D., President of the Royal Society of Canada, and President of the Geological Section, British Association, 1925, will read a paper on "The Mineral Resources of Northern Ontario."

SIR RICHARD REDMAYNE, K.C.B., M.Sc., M.Inst.C.E., M.I.M.E., M.I.M.M., F.G.S., late Chairman-Governor, Imperial Resources Bureau, will preside.

Tea and coffee will be served in the Library from 3.45 p.m.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

THURSDAY, JUNE 18TH, 1925.

THE RT. HON. J. H. THOMAS, M.P., late Secretary of State for the Colonies, in the Chair.

THE CHAIRMAN, at the opening of the meeting, said it was a real pleasure to him to accept the compliment of being invited to preside over such a distinguished gathering. Twelve months ago he had the honour of controlling the destinies of the Colonial Office, and on the present occasion he was taking the chair for one of his successors in that Department. He absolutely refused to express any opinion upon the merits or virtues of the change; he would rather leave that for the political platform. But whatever the political differences and party labels might be, there could be no doubt that whoever was called upon either to administer or to take an interest in Colonial matters could not be long in the Department without being brought face to face, not only with the problems but the wonderful possibilities of Africa. Going to the Department as he did more handicapped probably than his predecessors or successors but no less determined to do the right thing, he often felt that when they talked of the great British Empire, of its past and its possibilities, no one seemed to have yet realised the part Africa must play in the future. The British Empire was essentially a trustee in Africa, and no narrow interpretation must be placed upon that word. Trustee meant, if it meant anything, that for those millions of people they must always be determined to do the right thing, but equally they must be prepared to encourage, help and protect those settlers who played the part of pioneers; and above all help and encouragement must be given to those responsible for the administration on the spot. No man could sit in Downing Street and assume that he could run the British Empire. He wrote a book on how to govern the British Empire, but he never remembered, when any of the problems connected with it were brought home to him during his term of office by his very highly efficient staff, ever once saying to them, "Turn to page 42 of my book and you will find the answer." He soon discovered, what all practical men discovered, that the only way to do the right thing was to face the facts as they were; not to be blinded by past prejudice and even forget some of the speeches that one had made, being determined to deal with facts as they existed. He was so struck with the wonderful possibilities as well as the necessity of tackling the African problem in its broadest and widest sense that he determined to have first-hand knowledge. He was still in hopes that he would be able to visit East Africa. When he asked the Commission, which included as Chairman the author of the paper about to be read, to go to East Africa, difficult as was the task Mr. Ormsby-Gore readily accepted it. Those who had had the advantage of the friendship of Mr. Ormsby-Gore knew the keen interest he had always displayed in such problems. He (the Chairman) was quite sure Mr. Ormsby-Gore learned much while he was in East Africa; but was equally quite sure that he would be unable to do all he would like to do in connexion with that country. The Labour Party would "ginger" him up in that respect, and give him that assistance which some of his friends lacked.

The paper read was :—

SOME AFRICAN PROBLEMS.

By Hon. W. Ormsby-Gore, M.P., Under Secretary of State for the Colonies.

Just about a year ago the Royal Society of Arts was honoured by the visit of Monsieur Louis Franck, some time Belgian Minister of the Colonies. Monsieur Franck then read a both valuable and interesting paper on the Belgian Congo, and the two salient features of that paper dealing with development in Tropical Africa were, first, population, and, secondly, transportation. Everything that I have since learnt, both during my recent tour through the British territories in East Africa, and by my study of African problems on both sides of the Continent, leads me to the same conclusion which Monsieur Franck had reached, namely, that our first great problem in Africa is population and the second is transportation. These are the two first and most vital problems; but to them I would add one more, namely, scientific agriculture.

I feel that the study of these questions requires a comprehensive view and that the first thing we have to do is to assemble the facts. I define Tropical Africa as being that central portion of the Continent which lies to the south of the Great Sahara Desert and to the north of the Zambesi River. This vast fertile and well-watered stretch of the earth's surface comprises over 5,000,000 square miles (Great Britain is 90,000 square miles). Of this area nearly half is under British administration, being comprised of 1,000,000 square miles for the five British territories in East Africa, 1,000,000 square miles for the Anglo-Egyptian Sudan, and half a million square miles for the British West African Colonies. After Great Britain, with two and a half million square miles, comes France with 1,500,000 square miles in West Africa; Belgium third with 900,000 square miles in the Congo; Portugal fourth and Spain fifth. The British territories have an approximate aggregate population of 42,000,000, i.e., about the same as Great Britain. The French area has a population of about 12,000,000, as also have the Belgian territories.

The first fact that emerges from these figures is that the present population is extremely sparse, and wholly inadequate for the full development of the vast potential resources of the area. The next fact that emerges is that we have very few reliable data regarding the question as to whether this small population is increasing, is stationary, or decreasing. As far as British territories are concerned, such statistics as there are would seem to show that the population is definitely increasing in the Gold Coast, Nigeria and in the Sudan; for the rest the best that can be said is that there is no conclusive evidence that it is actually decreasing. But as regards the five British East African territories I think it is pretty clear that there has been little or no natural increase during the last 20 years. The war, of course, created very great disturbance and loss of life in East Africa, and is a factor which should not be lost sight of. Fairly reliable census returns are available in the case of the Gold Coast; in 1901 the total population was found to be 1,549,000; in 1911 the figure for the same area was 1,503,000, showing a small decline; and in 1921, 2,110,000, a fairly substantial increase, but how far this increase was due to immigration and how far to natural increase is not clear. The Nigerian census for 1911 gives a total of 17,133,000 and the 1921 census 18,070,000. As far as I can gather from the figures available, the population of French West Africa shows a very slight increase, while the Congo shows a pretty substantial decrease since the commencement of the régime of the Congo Free State under King Leopold, though now the tide has turned. These comparatively small increases in tropical Africa are in contrast with the conditions obtaining in South Africa, where, in some parts, the native population has doubled in 25 years, and where there is almost universally a high percentage of increase.

The outstanding feature of African tropical life is the enormously high rate of infantile mortality, particularly during the first twelve months of life. This probably accounts in a greater degree for the smallness of the population than the incidence of endemic and epidemic diseases later in life, though these are still taking gigantic toll. There are, of course, the somewhat spectacular epidemic diseases of which sleeping sickness is the most serious and the most widespread, and which, during the great outbreak in Uganda, wiped out one tenth of the total population in one year. But there are other diseases which are of quite as great importance, not merely in the high rate of mortality for which they are accountable, but still more on account of the enfeebling condition which deteriorates the efficiency of the individual and undermines his or her vitality and resistance. I refer, of course, to malaria and other mosquito-borne fevers, to venereal disease, to yaws (a contagious, but non-venereal disease somewhat similar in character), and to helminthic (worm) diseases, of which ankylostomiasis (hookworm) is the most important.

In addition to these diseases of outstanding importance we must add plague, leprosy, dysentery, spirillum fever, relapsing fever and smallpox. Of these plague is conveyed by rats, or rather by fleas living on rats, and spirillum fever by ticks, relapsing fever by lice, the others being contagious or infectious diseases more familiar to us who live in European conditions. In the main, it would seem that the fight for human life in Africa is in no small degree a fight of man against insects, a fight against the tsetse fly and the tick, the mosquito, the flea, and the louse. Both the tsetse fly and the tick play an equally important part in the veterinary sphere and the various diseases of cattle and other domestic animals are closely allied, and in the case of the tsetse fly absolutely bound up, with the human aspect of the problem.

From this thesis you will rightly draw the conclusion that the work of the medical and sanitary services is of supreme importance in Tropical Africa. It is important, of course, in European countries, where the strides made during the last century have been truly remarkable, but in Tropical Africa we are still only at the beginning of things, and as yet only touching the fringe of the problem, and the amount to be done far exceeds in scope and urgency that which is required in any other part of the world. As will be expected with such tremendous leeway to make up the efforts of the various Administrations, have necessarily been directed to the alleviation of suffering and the actual treatment of patients. Preventive medicine, to use the usual term, which means sanitation, research and administration, are even more in their infancy than clinical treatment. The importance of these aspects of the problem are now generally recognised and efforts are being made to face the issues.

The proportion of tax revenue devoted by the various territories in British East and West Africa to medical and sanitary services is increasing, but at best it is still small compared to the magnitude of the task. The amounts are :

Gold Coast	18%
Nigeria	10.5%
Sierra Leone	11%
Uganda	17.5%
Tanganyika Territory	14.1%
Kenya	7.5%

Population is the first limiting factor in African development, whether that development be by means of native production or plantation system. Apart from production it plays just as great a part in the problem of distribution. It is no use organising the production of increased wealth unless there is labour available to move the produce. The rapid expansion of native agricultural production in both Uganda and the Gold Coast has already given rise to serious labour problems. There is terrible congestion of cotton in Uganda at this moment, due in the main, not so much to any deficiency of rolling stock or facilities on the Uganda Railway transportation system, as to scarcity of labour in moving the ginned cotton on to railways and steamers. In order to construct the new railway in Uganda, we have been compelled to bring down large numbers of natives from the West Nile district, which the transport system does not reach at present, both for construction and distribution purposes.

The native cocoa producers in the Gold Coast Colony are still fortunate in being able to get the services of labour from the neighbouring French territories and from the northern territories of the Gold Coast, which are as yet too far from developed transport to be able to produce for export themselves.

Similarly the plantations of Kenya and Tanganyika are already short of labour for the adequate development of the estates. Therefore, whichever means of economic development are adopted in Tropical Africa, it is perfectly clear that we shall be blocked, not for want of land or want of capital, but primarily for want of human agencies in all their diversity required in connexion with any economic activity.

If we are to build up in East and West Africa anything in the nature of a peasant proprietary, larger families are an economic necessity, for it is only where there are sufficient members of a family, not only to cultivate the land and harvest the crop, particularly such a crop as cotton, but also to provide labour for all the other social services which are necessary to get that crop on to the sea, that there can be any permanent stability in expansion. The first concern, therefore, in which governments, planters, traders and native producers alike, are all equally interested, is to secure an increase in the native population.

There is one Tropical Colony from which we have much to learn, namely Java, which has very nearly doubled its native population in forty years, and in that interval has increased its production, both native and plantation, by something like five-fold.

The problems which we have to solve are not merely questions of social economics but questions of life.

I now turn to the question of transport. One of the outstanding examples of the waste of human labour in the world to-day is the widespread use of "carriers" in Tropical Africa. In the aggregate, many thousands of tons of produce every year are still being carried, often for great distances, by human porterage. The absence of roads restricts the areas where wheeled transport of any kind is possible, and over very large areas of Africa where roads or tracks do exist animal transport is ruled out by the prevalence of the fatal tsetse fly.

Road making and road maintenance present special difficulties in Tropical Africa. A great part of the area is covered by a thick coating of soil, the result of the growth and decay of centuries of forest and other vegetation in a land of high temperature and high rainfall. In this connexion few things struck me more than the sight of the railway cuttings on the new railway construction in the Kenya Highlands. Before the rock, or even a gravel formation, is reached, you have to cut through a section of anything between thirty and forty feet of rich loamy soil. In the dry seasons the surface of this soil is baked hard by the sun, but with the coming of the rains the so-called earth roads become seas of slimy mud, impassable for wheeled traffic. The intensity of the tropical rains makes the maintenance of gravel or metalled roads a serious and expensive problem, even where it is possible to obtain metal for the initial construction. Then in many parts of Africa the white ant seems to possess the tiresome habit of throwing up its architectural monuments in the middle of your road.

In spite of these special difficulties, the construction of roads has already played a very important part in the economic development of certain areas of Tropical Africa. It is not too much to say that the remarkable growth of the cocoa industry in the Gold Coast and the cotton industry in Uganda is due to the development of road transport. In Uganda I was especially struck by the influence of new roads in opening up both agricultural production and trade. The ever extending network of roads in Uganda is due, in the main, to the continuance of the obligation of the natives throughout the greater part of the Protectorate to work on the roads for one month in the year, while new roads are now being constructed by means of communal labour under a system whereby every adult male resident within a given distance from the new road is compelled to turn out for the work. Kenya and Tanganyika are very deficient in the matter of roads, particularly in the native areas. In West Africa the Gold Coast leads and has now 3,650 miles of good roads open for motor transport. Nigeria, which is one-third the size of British India, has at present only 2,500 miles of motor road.

The cost of motor transport in Africa is high, partly due to the present high cost of fuel and partly to the high rate of wear and tear. In order to protect the roads it has been found necessary in the Gold Coast to limit the size and weight of vehicles, and it may be that similar enactments will be called for elsewhere.

I am driven to the conclusion that the further development of Tropical Africa is essentially bound up with the extension of the railway systems. The railways can be used at all times of the year, wet or dry, and in spite of the high cost of the initial capital expenditure the railway in Africa is the most potent mechanical agency in the spread of civilisation and economic improvement. By the end of this year there will be open for traffic in the three West Africa territories of Nigeria, Gold Coast and Sierra Leone, approximately 2,360 miles of railway, and in East Africa, including all five territories, approximately 2,700 miles. In India there are over 30,000 miles of railway. Throughout British Tropical Africa we are, therefore, only in the initial stages of railway construction and are still engaged in siting our main trunk lines.

In East Africa we have to bear in mind the existence of the Great Lakes and the navigable portion of the Nile as invaluable collecting areas and as opportunities for the cheapest form of internal transport. Similarly, in West Africa we have the navigable sections of the Niger and the Benue as an important factor in railway strategy. In East Africa Lake Victoria and Lake Tanganyika are already connected with the sea by through railway communication. There remain Lake Nyasa and Lake Albert, both of which should be connected as soon as possible with ports of the east coast of Africa by means of through railway communication.

In the further consideration of railway strategy the next most important factor to be borne in mind is the density of population in any particular area and the capacity of the area to produce a sufficient quantity of produce to make the railway pay at a reasonably early date. It is therefore essential that in addition to the engineering survey for any projected line, there should be something in the nature of an economic survey at the same time.

I have alluded to the general sparseness of the population, but it is only right to point out that in particular areas there is considerable concentration. For instance, approximately one quarter of the total population in Tanganyika Territory lives in the area between Tabora and Lake Victoria. In this area there is a native population of over 1,000,000 of a progressive agricultural type, and yet it is one of the areas most threatened by the spread of tsetse fly and in which transport is rendered particularly difficult on account of this pest. A railway right through the area seems to me to be essential.

Turning to West Africa, there is a populous north-western area of the Northern Provinces of Nigeria which forms the most suitable area for cotton growing. But this rich and populous area is at present out of the reach of both railway and river transport, and only by the construction of a railway, or possibly two railways, can its potential riches be brought into being.

Save in those exceptional cases where expensive bridging or heavy grading is required, the cost of construction and equipment of new railways in Tropical Africa should not now exceed £10,000 per mile. Of this approximately half represents orders for rails, bridging work, cement and equipment unobtainable in Africa requiring manufacture in this country. In view of the depressed state of these particular industries in Great Britain, I feel that this is the time when every effort should be made consistent with native interests to expedite further railway construction in Africa, for such expenditure as is involved is really remunerative and the indirect benefits to trade and commerce are quite as important, if not more important, than the actual relief which these railway orders would afford us at this time.

The principal difficulty is initial finance. The bulk of the taxation in Tropical Africa falls upon the native and it is impossible to call upon him to pay higher taxes until he is in a position to pay them by producing commodities which he can market, and it is hard to throw upon him the high cost of loan charges during the period of railway construction, before the railway can operate to his advantage. It is the bridging of this comparatively brief gap that is the crux of the financial problem that faces each Colonial Government anxious to develop.

In many parts of Africa transportation facilities are actually behind the present production. In Tanganyika Territory considerable quantities of groundnuts grown by the natives could not be got down to the railway before the break of the rains last year and were consequently lost. This has a discouraging effect upon native effort. We are already faced with great difficulties in moving even the existing Uganda cotton crop, and owing to the congestion at the collecting centres of Uganda much of the crop is deteriorating in the open. There is grave congestion at all the East African ports for both inward and outward cargos, particularly at Beira and Mombasa. In fact, one is reluctant to encourage or stimulate further production until the present transportation difficulties have, in some measure, been solved. In view of these facts I feel that it is quite legitimate to divert temporarily from agricultural production a great deal of native effort to labour on railways and roads, which will alone stabilise the welfare of the agricultural producer.

I think I have said enough to emphasise the urgency and importance of the transport problem and I turn to my final subject of agriculture. I do not propose this afternoon to enter into the vexed controversy of plantation versus peasant cultivation, but I do wish to emphasise the fact that native production cannot possibly succeed in the long run without the guidance and help of a considerably augmented staff of European scientifically trained agricultural officers. Further, not only do we require the agricultural staff in order to ensure the quality and better cultivation of crops, but we also need a great deal more research in the science of tropical agriculture. In the past we have left these two questions very largely to chance, and to the individual

APPENDIX.

	Area Sq. miles.	Estimated population.	Revenue 1924. £	Domestic Exports. £	Railways open (miles). (1924.
NIGERIA	*368,000	*18,631,000	6,329,250	10,885,000 (1924)	1,126
GOLD COAST ..	*91,690	*2,296,400	3,667,000	7,600,000 (1924)	394
SIERRA LEONE ..	27,250	1,541,000	857,928	1,347,000 (1924)	338
KENYA	245,060	2,500,000	1,936,000	2,240,000 (1924)	950
UGANDA	94,000	3,000,000	1,232,000	3,892,000 (1924)	50
TANGANYIKA ..	365,000	4,200,000	1,387,000	2,611,000 (1924)	1,017
FRENCH WEST AFRICA ..	1,385,000	12,500,000	2,267,000	5,535,000 (1923)	1,795
BELGIAN CONGO	909,654	15,000,000	1,409,000	5,044,000 (1922)	1,273
ANGOLA (PORTUGUESE) ..	484,709	5,000,000	1,182,000	1,572,000 (1922)	818
JAVA AND MADURA ..	50,700	37,000,000	54,623,000	72,416,000 (1923)	1,895

*Including Mandated Territories of Cameroons and Togoland.

effort of the different Colonial Administrations and a handful of officers. The time has come, in my opinion, when we must regard the British Tropical Dependent Empire as very largely one for this purpose. The first big step in the right direction is the establishment on a really effective scale of the Imperial College of Tropical Agriculture in Trinidad, an enterprise peculiarly associated with the late Lord Milner. A public appeal for funds for this all-important college has so far met with inadequate response, and I do hope that before many months have passed something more will be done to establish it on a sound financial basis. Similarly, I hope it will be possible to reopen on a considerable scale the wonderful German Research Institute at Amani in Tanganyika Territory.

Just as human beings in the Tropics are subject to the attacks of special diseases so domestic animals and plants are similarly attacked. There is a vast field open for scientific work and it is only, if we can get the amount of money for this purpose, that we can hope to achieve some measure of success in the solution of the problems.

DISCUSSION.

THE CHAIRMAN, in inviting discussion, said he thought Mr. Ormsby-Gore had justified the remarks he (Mr. Thomas) had made in introducing him to the meeting. Whatever might be the failings of the Colonial Office in the future, they would not be due to the ignorance of the Under Secretary or to the want of that great human sympathy which he had shown towards the particular problem under discussion.

THE RT. HON. SIR FREDERICK LUGARD, G.C.M.G., C.B., D.S.O., said he thought Mr. Ormsby-Gore had rightly summed up the whole of the African problem in the two words "population" and "transport," for out of either of those words practically every problem in Africa arose. Mr. Ormsby-Gore had dealt in detail, with a wonderful grip of the essentials, with each of those problems in the Report which had been issued as the result of the Commission in East Africa of which he was Chairman. The appointment of that Commission was due to Mr. Thomas, and it was remarkable in that it consisted of three men, one belonging to each of the three parties in the State. In every public pronouncement that the Chairman had made he had always emphasised the great principle that the study of the African problem should be something above party. If he could succeed in inducing the British public to adopt that principle he would have achieved very much more than any of his predecessors at the Colonial Office. If anyone present who was interested in the African problem had not read the Report of the Commission over which Mr. Ormsby-Gore presided he should do so. It was a notable work, which could only have been compiled by a man who had given prolonged study to the different subjects dealt with before he went out to East Africa and who knew the various points upon which information was desired. It was stated in the Report that the Commission was absent from England only 19 weeks, five or six of which were spent at sea, and under those circumstances the result that had been produced was truly monumental. Dealing with the two principal subjects of transport and population, the members of the Society listened at a meeting not very long ago to a paper on the transport question. Generally speaking, the argument of the author of that paper, with which he cordially agreed, was that arterial railways were amongst the greatest essentials in Africa. Some controversy had arisen as to what was the best class of feeder for the railway. The reader of the paper to which he had referred maintained that roads were not the best class of feeder. Mr. Ormsby-Gore stated in his Report that a metalled road in Africa was estimated to cost about £2,000 a mile, while railways were now being constructed in East Africa for only £3,000 a mile. One of the speakers, the late Sir William Acworth, had stated that, in his opinion, even the era of branch railways had gone by, and that in future the development of the caterpillar system of transport of vehicles running on the rail track system, which were able to cross the country without any kind of road, and even to improve the track over which they passed, would not only supersede narrow gauge branch lines but even more substantial lines of railway. They did not, however, supersede the great necessity for arterial railways, particularly the two railways which the author had emphasised for which he wished to raise a loan for East Africa. A railway from the north end of Lake Nyasa to connect with the port of Dar-es-Salam and Tanganyika, and an extension to relieve congestion in Uganda were both arterial systems and urgently needed. The subject of population was not only concerned with the material development but also with the welfare of the native population. The author had stated that research was necessary into the reasons why the populations in British territories in the tropics in Africa were either stationary or decreasing. He agreed that that was most essential, but the organisation of any system of research on a large scale would take some time; and he had ventured previously to suggest that something might be done immediately if the Colonial Office were to invite the Governors of those different territories to consider with their various experts, including medical and agricultural, some of the prominent questions as to why the population was decreasing. The reports on the subject which would then be submitted might form very useful preliminary data for a larger system of research which might follow later on. Questions arose, for instance, as to whether the decrease of population could be arrested by better medical appliances, by the employment of women doctors to deal with infantile mortality; whether the decrease was due to the breakdown of the tribal systems and the sanctions of the native organisation which in the old days was able to maintain a progressive population; whether, on the other hand, the cause was undue demand for wage labour, and if so what substitutes could be applied. These were questions on which those who had long experience on the spot could afford very valuable data, at any rate as a guide in regard to the points on which more accurate information was required. The Belgians had come largely to the conclusion that a redistribution of the population would be a method of arresting the decrease, which was very marked in the Belgian Congo. The development of Africa was the problem of the 20th century, which had been temporarily postponed and delayed by the war and the aftermath of the war; but under the present Secretary of State, Mr. Amery, and Mr. Ormsby-Gore, it looked as if progress would be made. They were both deeply interested in the subject and they had supporting them in Opposition the Chairman of the meeting. He desired, in conclusion, to ask Mr. Ormsby-Gore one question. A most important pronouncement had been made within the last few days by Lord Balfour in the House of Lords in regard to the appointment of an Imperial Civil Research Committee. Could Mr. Ormsby-Gore state what were to be the functions and scope of that Committee, and how far would it assist in the research which he was so anxious to institute? He desired to add his personal thanks to Mr. Ormsby-Gore, not only for the paper he had read but for his Report, for which every African Colony and Protectorate owed him and the other members of his Commission a debt of gratitude

Mr. Max M. Kay (Chairman of the East African Committee of the Manchester Chamber of Commerce) said that coming from Manchester he was naturally inclined to look upon things more from the commercial side, but he could assure all those present that the commercial man, whether exporter or importer, could not carry on trade without the pioneers who prepared the ground for him. There was ample room for still more pioneer work, especially in Africa, as had been amply proved by Mr. Ormsby-Gore. The remarks he had made on the present occasion covered only a small portion of a much larger Report which, together with two other gentlemen, he recently compiled after their mission to East Africa. He considered that that Report was one of the finest achievements from a literary as well as from a practical point of view that had appeared for a very long time. In view of the enormous area of the territory visited and the many subjects which had to be considered he could only marvel at the rapidity and the completeness with which that Report had been produced. He agreed that it was absolutely necessary to look after the population, which he placed even before transport, because transport would follow if men and goods were produced. When he recently had the pleasure of meeting Mr. Ormsby-Gore he had just left a meeting of the International Conference on Tropical Diseases, with special reference to the problem in Africa. He (Mr. Kay), looked forward to great results following from that annual international effort to combat the ravages of both human ailments and insect pests. He was sure also Mr. Ormsby-Gore was convinced of the need for impressing on Parliament that the grants of loans required for Colonial enterprises should be ungrudgingly made, for without them they would be met with that big bugbear of all development—no money, no facilities; no facilities, no commerce; no commerce, unemployment.

Mr. F. C. Linfield, a member of the Commission, said he had attended the meeting for the purpose of showing his appreciation of the services of the Chairman of the Commission, Mr. Ormsby-Gore, and also in order to take the opportunity of thanking Mr. Thomas for appointing it. So far as he and his colleagues were concerned he thought they had succeeded in lifting the question above all party political purposes. He had given expression to certain views of his own, he would not say in a Minority Report, because he felt that he was at liberty to give expression to those views. The Commission were greatly indebted to Mr. Ormsby-Gore for the knowledge he possessed before they started, and for the way in which he directed the enquiries in the great territories that were visited. He desired to bear his testimony not only to the broadness of view of Mr. Ormsby-Gore but his broadness of sympathy. His colleague, Major Church, would bear him out in saying that they were distinctly encouraged by their Chairman to look into everything, there being no desire on his part to colour the views of the other members of the Commission by his own particular point of view. They went loyally to work as colleagues representing each of the political parties; but above everything they went loyally to work for the purpose of trying to help the Empire.

Major A. G. Church, D.S.O., M.C., also a member of the Commission, said he was gratified to hear Mr. Ormsby-Gore remind the audience that scientific research was at the very basis of any sound development of our imperial resources, that, with its vast responsibilities to the world as a whole, the British nation could not afford to lag behind in matters of research. He recommended the audience to read the Report of the Commission, and particularly that part dealing with the Amani Institute. Lord Balfour quoted a statement made in the Report, that the only activity of that once famous institute was the distribution of small packets of seeds. When he and Mr. Ormsby-Gore visited the Amani Institute, they found white ant hills pushing through the roofs of some of the buildings. Neglect of Amani, he was afraid, was symptomatic of our administration of our Empire, and Great Britain did not deserve to retain the Empire if that sort of thing continued. It could not be expected, however, that the results of research would be communicated within a short time to the practical man. There was always a tremendous gap between scientific research and practice, and an endeavour was now being made to bridge that gap. If this nation did not do its best to reduce the gap other nations which were much more alive at the moment to the importance of scientific research would take the lead which had been held for so many years by this country, although other nations did not possess certain natural advantages which the British nation did.

Miss Euphania Smith suggested that all the facts which the Commission over which Mr. Ormsbv-Gore presided and all the work which had been done by the many Societies which were working for the betterment of the British Empire should be concentrated into one scheme with the object of bringing about unity in work. There were many difficulties that had to be faced in connexion with insects, for instance, in South Africa, where the locust was very troublesome. If a concentrated scheme of that kind could be established it would prevent the work being spread over different Societies and different methods of research being established. She had no doubt that the money would be forthcoming for the purpose. She hoped the Chairman would use his influence with the other leaders of his party to endeavour to bring the masses of the country into line with his views, and if that was accomplished work would be done for the Empire of which every one would be proud.

Mr. R. C. Hawkin said he had been greatly impressed with the remarks Mr. Ormsby-Gore had made in regard to the success that had been achieved in Basutoland, which was the outstanding success of British administration in Africa. This was evidence that a native territory must retain its tribal system if administration was to be a success. Mr. Ormsby-Gore had referred to the danger of breaking up the tribal system : transporting large bodies of native labour from one part of Africa to another was a grave detriment to the native population. There was at the moment great unemployment in this country and on the other hand an outcry for labour in Africa. Was it impossible to formulate a scheme for providing one part of the Empire with labour from another without unnecessary disturbance ? He noticed that the Chairman shook his head, but Colonel Creswell in South Africa was considering the problem, and putting forward certain schemes for using white labour a great deal more than had hitherto been the case. He believed, in spite of the Chairman's doubts, that it would be possible in the long run to build a railway in Africa with English labour. It had been done before and it could be done again.

M. Pol le Tellier (Councillor of the Belgian Embassy) said that the Belgian Ambassador would be exceedingly sorry when he learned that, owing to his absence from London, he was prevented from being present at the meeting. If Baron Moncheur had been there he would have felt the greatest pleasure, as he (M. Le Tellier) did, in listening to his friend Mr. Ormsby-Gore, with whom he and many of those who belonged to the Belgian Colonial world had always enjoyed the most cordial and useful relationship. The Under Secretary of State for the Colonies had exposed with great lucidity the three vital problems on the solution of which the rational development of tropical Africa depended. He reminded them that two of those problems had already been discussed at the Royal Society of Arts by M. Louis

Franck, formerly Belgian Minister of Colonies, and one of the best informed of his countrymen on colonial matters. The work of civilisation in the Congo which was undertaken by Belgium, thanks to the foresight and tenacity of their illustrious late Sovereign King Leopold II, was now beginning to reap the benefits of the efforts expended. The start was beset with difficulties, but, as the years had gone by progress had increased, and at the present time, in the reign of King Albert, Belgians felt that they had deserved the gratitude of the natives as well as the appreciation of those countries which were familiar with the results of their labours. The present colonial powers in Africa were all on terms of friendship, and as nothing separated them they could work in complete unity for the common good of the native populations; by the happy combination of those efforts general prosperity would be increased. Belgians had often sought inspiration for their Colonial policy in the teachings of British experience, and they owed Britain much. They had always wished to have England's valuable sympathy on their side in their colonial development, and knowing that they could count upon it, it gave them particular pleasure each time they could, in their turn, have the opportunity of seeing Britain derive any benefit from their observation and their experience. He was happy to be allowed to thank Mr. Ormsby-Gore most heartily for the homage he had paid to Mr. Franck, and for the very instructive information he had given them on Tropical Africa. In the display at the British Empire Exhibition at Wembley the marvellous riches of that region were brought home to them, and were a striking proof of the wealth that lay behind the British Empire and the confidence which might be felt in its future.

DR. ARTHUR HAYDON, M.D., thought there was a great necessity, from the point of view of health, of suitable buildings being erected in the tropics in which the women could be collected, particularly during childbirth and the upbringing of infants, so that they would not be so liable to the attacks of insect pests. He also desired to ask why the British Government adopted the policy of refusing to allow Englishmen or other Europeans to hold freeholds in any part of the Empire under discussion. In his opinion the great problem that had to be solved in Africa related to hygiene, sanitation and the erection of suitable buildings, which would act as preventatives, rather than the use of quinine and other drugs in the treatment of disease when it occurred.

SIR CHARLES C. MCLEOD, in proposing a hearty vote of thanks to Mr. Ormsby-Gore for his excellent paper and to Mr. Thomas for his kindness in presiding over the meeting, said it was very refreshing indeed to find such political opponents great personal friends. But that was the way in politics. Members shook their fists at each other inside the House of Commons and shook hands the moment they got outside it. Speaking as one who had lived abroad for most of his life, he was able to say that in all matters connected with Colonial extension the greatest possible help had always been received from the Colonial Office, not only from the present Minister, but previous Ministers, including Mr. Thomas. The only remark he desired to make in regard to the paper was that quite recently a very important college had been opened for research into mosquito malaria by Sir Ronald Ross, and he commended that fact to the notice of Mr. Ormsby-Gore.

COLONEL SIR CHARLES E. YATE, Bt., C.S.I., C.M.G., in seconding the motion, said he had noticed with pleasure that Mr. Ormsby-Gore had brought to their notice the fact that the material prosperity and progress of Uganda were greatly due to the obligation of the native to work on the roads for one month in each year.

Uganda was the one province in East Africa that was primarily ruled by its own native chiefs, and a tribal system existed in that country which he trusted British administrators in other parts of the colony would follow. He hoped the Chairman would lose no opportunity of impressing on every one concerned the necessity of East Africa following such tribal customs, and not being led away by any new-fangled doctrines to the contrary. It was only by following such tribal customs that the roads and railways that were so necessary for the prosperity of East Africa would be constructed.

The motion was carried unanimously.

THE HON. W. ORMSBY-GORE, after expressing his gratitude for the hearty manner in which the motion had been passed, said he desired to take the opportunity of thanking the Chairman for so kindly occupying the chair that afternoon. Mr. Thomas was responsible for sending him out to Africa and for his continued interest in the subject, and he hoped he would not regret it. He also desired to thank M. Tellier for attending on behalf of the Belgian Ambassador, and to say with what importance he regarded international co-operation in the problem. He had read the most valuable reports that had recently been issued in Belgium with regard to some of the problems on the Congo, particularly the labour problem and the problems connected with the great oil palm plantations, which were of the greatest economic importance in the future of Africa. M. Tellier had said that Belgium had taken hints out of the British book of experience, and personally he was able to say in return that he was sure this country would obtain valuable experience from the work of Belgian officers in the neighbouring country of the Congo. The communications, into and out of the Congo, were very largely through British territory at present, and he believed would continue so for a long time to come, so that it was essential the two countries should work together. In reply to Sir Frederick Lugard's remarks, he thought it would be necessary to leave it to Lord Balfour to define exactly what he intended his Committee to do. He (Mr. Ormsby-Gore) attended the first meeting of the Committee that morning, but it was too early to judge how the Committee would shape in the future. In reply to Mr. Hawkin, who raised the question of white labour in South Africa, he wished to say that his lecture was confined entirely to Tropical Africa, and he did not believe that any part of that area was fit for the ordinary white worker. He certainly could not do manual work during the greater part of the day; but apart from that, the white women and children had also to be considered, because nobody wanted the white man to be in large numbers in Tropical Africa without his wife and family. The idea that white women should go out to bring up white children under tropical conditions without very frequent leave in England was very dangerous. The problem of white children in the tropics was an acute one, and personally he would never do anything to encourage the migration of European labour to Tropical Africa. In reply to the speaker who asked a question in regard to freehold land, it must be remembered that the conception of freehold land was alien to Africa and the African. It was a matter that vitally touched the social evolution and development of the people that European and alien conceptions of laws and customs should not be forced upon people of that kind. It would absolutely smash the tribal system which it was desired to preserve if the idea of freehold land was enforced in West Africa, where they had always regarded land as belonging to the African. That had been the basis of the British Protectorates; and the view of the Government was that in their present state of development it was necessary to do everything possible to protect the native from the moneylender and the usurer. With regard to freeholds for the few highland areas where European settlement was possible, he thought that in developing countries in which the major part of the expenditure came from the British or the local taxpayer and the question of where the railway went made a whole difference to the value of land, long leases should be granted as against freeholds. If a freehold system was instituted it would be necessary to have special land taxation as well. It was much more likely to encourage development if a person were given a long leasehold, but making it clear that the community which expended the money would, at the end of 99 years, be able to raise the rent and get something back for the improvements which had been made, not by the man who had the land but by the community and above all by the British taxpayer. The vital thing was prevention rather than cure. There were few questions more urgent in Africa than the problem of housing and sanitation. He fully endorsed all that had been said in regard to the magnificent work that was being done in the maternity centres, particularly throughout Uganda. Two great missions with two remarkable women at their head had done work which would be absolutely outstanding in history. They were training the native girls as midwives, establishing maternity centres, and raising the whole standard of maternity problems and infant welfare. The work was spreading with astonishing rapidity, and would prove of tremendous importance not only in regard to the economic development but the happiness and progress of the community. Personality counted in matters of that kind, and if only two such women could be found in every colony to carry out similar work results of supreme value would be obtained.

THE CHAIRMAN thought the Report which had been presented by the three members of the Commission would become historical. It was no good treating it in the same way as a report of a Royal Commission. If something was to be done it ought to be done at once, because in the development of the question he did not dissociate altogether the internal troubles of this country. He shared Mr. Ormsby-Gore's views in regard to tropical work and the emigration of white people. He knew something of what Major Creswell was doing in South Africa; and so far from there being any question of white people going out there the real problem in South Africa was the native Indian problem, which was far more serious than any talk about emigration to South Africa. It appeared to him the Government would be making a mistake if they delayed tackling the transport problem. It could not be an immediate commercial advantage and it was not right to expect the native to bear the immediate burden, but ultimately the native would benefit and the trade of this country would benefit. There had never been a time when unemployment was so terrible at home, and if money was to be spent it should be spent at once on such work instead of pouring money out on the dole.

PROFESSOR SIR WILLIAM J. SIMPSON, C.M.G., M.D., writes:—

I listened with much interest and admiration to Mr. Ormsby-Gore's very informing lecture. His clear insight into the problems of Tropical Africa are due, in no small measure, to his visit there and to his former experience in Egypt and Palestine. He has given a very vivid picture of the serious effect of disease on an extremely sparse population and its ultimate interference with the much-needed development of transport and agriculture if hygienic measures on a larger scale than at present are not introduced. It is evident that the problems are difficult to solve, particularly that relating to population, but I venture to think that they are not more difficult than those which have already been solved by the pioneers of our Empire in Tropical Africa. It is to the men of the 19th century, supported by the people in England, that we owe the abolition of the slave trade, human sacrifice and intertribal wars, which were then the three main factors in the reduction of the population of Tropical Africa. This achievement set free forces favourable to the gradual material and moral progress of the inhabitants of East and West Africa, and at the same time presented opportunities for commerce and agriculture which have resulted in the great commercial development of the 20th century.

True the African Problem of to-day in regard to the condition of the population is different. Less striking in its character, it does not appeal to the public in the same way. Disease is not generally recognised as a powerful enemy to the welfare of a community; unless there is some rapidly-spreading epidemic causing much destruction of life and dislocation of commerce and labour, such as we have had in comparatively recent outbreaks of plague, little interest is taken in measures for the suppression of disease. The annual deaths from endemic diseases are viewed as natural and as a matter of course. Accordingly there is no strong public opinion to encourage the necessary expenditure on the preservation of health and the prevention of endemic disease. It is viewed as an unproductive expenditure, and hence the usual reply to a suggestion for the adoption of hygienic measures: "No funds available." The proportion of tax revenue devoted to medical and sanitary services quoted by Mr. Ormsby-Gore does not redound to the credit of Kenya.

The East Africa Commission appointed by the Right Hon. J. H. Thomas, when Secretary of State for the Colonies, and of which Mr. Ormsby-Gore was Chairman, have expressed in no uncertain terms in their report their disappointment at the little that has been done during the last twenty years in endeavouring to solve the problem of the prevention of sleeping sickness. The result of that report is most satisfactory in that an expert Commission is being sent out to study the problem.

The great value of Mr. Ormsby-Gore's lecture is that it will waken people up in this country to the important fact that diseases, such as plague, malaria, anchylostomiasis and other common preventable diseases are having a very serious effect on the African population, especially in the British possessions, which represent half of the vast area of more than five million square miles of Tropical Africa and which contains the largest population. From personal experience I agree entirely with the views set forth in the lecture. I hope that the ten million pounds loan will be granted for East African developments, and I would like to add that besides the money raised by local taxes for sanitation, there should be another loan of 10 millions to secure for each of the several territories an adequate Public Health Service to save the population from preventable disease. The causal agents of most of these diseases that the Africans suffer from, their methods of attack and the conditions which favour their spread are known. This knowledge is of little value unless an active and increasing campaign is waged and maintained against such diseases. For this a permanent sufficiently large and efficient staff and organisation, including laboratories and other adjuncts or branches necessary for a complete Public Health service, is required in each of the territories, which cannot be had unless a sufficient sum of money is set aside for that purpose and so secured that it cannot be diverted.

MR. R. H. BRACKENBURY writes :—

In Tropical Africa to-day, it is not the handling of the large, but of the small, amounts that presents the difficulty. The transportation of large quantities of produce down to the seaboard is no more than a financial problem. If the amounts to be carried are sufficient in quantity and value, then the construction of a railway to deal with them is a logical necessity, which will be met as soon as the necessary funds can be provided.

The difficult problem is the transportation of the comparatively small amount—the provision of transport services which will tap the little communities sprinkled all over the 5,000,000 square miles of Tropical Africa and bring their produce down to the main arterial railways. In other words, the establishment of adequate feeders to the railways.

It has been suggested that this need can be met by laying down a system of macadamised roads. But macadamised roads require a large amount of labour for their construction and absorb a great deal of labour for their maintenance, so that in a country which averages a population of from 10 to 15 per square mile, they must of necessity be very few and far between, which is apt to have the result that a road is paid for by taxes collected over a much wider area than it serves. The same thing happens with a railway that is losing money. The benefit and advantages of the railway are confined to the narrow strip which it traverses, but the losses are made good from the revenues of the whole Colony.

Now a native does not have to be very far away from a road or railway to derive very little direct benefit from it. If his home is, say, 70 miles from the nearest point, it would take him a full year to carry only one ton of produce to it. But if he spends six months of the year at home growing his crops and the other six months as a pack animal, he can only carry half a ton to the road or railway 70 miles away. That is not a very sound commercial proposition.

I have the privilege of serving on a committee formed by the Empire Cotton Growing Corporation for the consideration of the best means of transporting cotton from the field or ginnery to the nearest railway or port. While we recognise that macadamised roads will be established wherever they can economically be built and maintained, we do not believe that they provide a solution for the present impasse, simply and solely on the grounds of their expense.

There are hundreds and thousands of villages sprinkled all over the 5,000,000 square miles of Tropical Africa, growing valuable produce in excess of their immediate needs, and the total is really imposing. The individual amount in many cases is, however, too small to justify the construction and maintenance of a macadamised road. In the view of our Committee, the only way to bring in this produce is to make use of that new type of roadless vehicle mounted on flexible tracks, now being perfected, which does not require a macadamised road, but only a way through the jungle or veldt cleared of boulders and tree stumps. Such vehicles can carry really substantial loads and yet exert no more pressure or destructive influence on the ground than a native's bare foot, which all of us who have lived in Tropical Africa know tends rather to flatten and consolidate the ground than to cut it up. Such vehicles, probably propelled by some more economical power unit than the petrol engine, provide, in our view, the most hopeful solution of this Tropical African transport problem.

We are now engaged in carrying out tests with some of these vehicles, and while I will not enter now into an account of the details which, in any case, will be published later and made available to any one interested, I am able to give the assurance that the results so far have been extremely encouraging and most impressive.

MR. G. M. RYAN writes:—Mr. Ormsby-Gore, in his extremely interesting and able remarks, emphasised the great necessity of railway construction in Africa to secure its speedy commercial and economical development; but no mention at all was made by him of aerial transport as a means of helping to solve the problem.

Bearing in view the enormous physical difficulties to be overcome, and the great danger to health and life which besets the residents in Africa from the attacks of the tsetse fly and other insects, aerial transport would seem to be the more economical and efficient means of the two in overcoming difficulties that exist there. At any rate the dangers to health, if not entirely overcome by such means, would be greatly mitigated by traffic being conducted for the most part in the air rather than on land.

Most of the produce (viz., ground-nuts, cotton, etc.) to be conveyed, moreover, would apparently be such as would be well adapted for transport by aerial means, being light and portable. It has taken about 60 to 70 years for India to attain its present commercial development by railway means—and this is a much smaller continent, with richer resources, larger and annually expanding population and comparatively healthy climatic conditions. If we have to wait for opening up Africa on the same lines and in the same period, financiers can scarcely be expected to come forward with funds to assist in attempting to do so.

No. Aerial transport is what we should mainly fix our gaze upon, especially if a cheap indigenous liquid fuel can be found for the purpose, and this, I am of opinion, can be found. As I am engaged on research work of this nature myself at the present time for another part of the Empire, I shall be happy, if called upon, to indicate the lines on which such research can be satisfactorily accomplished in the African zone.

The African continent is so vast and distances are so great that railway transport, even if it could be made a paying commercial proposition there, would be a comparatively dilatory method for the carriage of goods from the hinterland to the coast. Two or three weeks would be required in many instances for the conveyance of produce to a port for shipment, whereas under aerial means the same produce could be conveyed in almost as many days.

By aerial transit, in fact, distances would be so annihilated as to reduce Africa to the present size of the British Isles for the transport of goods.

Employment under the scheme would be offered for many thousands of British airmen and mechanics, who would become trained for flight in the event of war in Europe or elsewhere.

In this age of rapid progress there can, it is thought, be no question in which direction and on what lines the commercial and economic development of Africa should be carried out, and I sincerely hope that my remarks on the subject may invite attention and meet with favourable consideration by all concerned.

THE PROMOTION OF FRENCH TRADE THROUGH EXHIBITIONS AND FAIRS

An interesting account of the efforts made to promote French trade by means of exhibitions and fairs is given in the Report on Economic Conditions in France by the Commercial Counsellor to H.M. Embassy in Paris, from which the following particulars have been taken:—

In France.—Trade fairs and exhibitions of various kinds have become to an increasing extent in recent years a prominent and regular feature in French commercial life; but a marked change has been perceptible in their general character in comparison with similar manifestations in the nineteenth century. After the great Paris Exhibition of 1900, few large exhibitions extending over many months were attempted in France (in 1906, 1907 and 1914, however, exhibitions of a certain magnitude were held at Marseilles, Bordeaux and Marseilles), and the long-period exhibition of the mixed business and attraction order fell into distinct disfavour with the commercial community, although the Brussels, Ghent and Turin Exhibitions showed the vitality of modified forms of such exhibitions in other European countries.

In 1901 was held in Paris what proved to be the origin of the prevailing type of fair in France, namely, a rather modest exhibition of toys and of articles de Paris, out of which sprung the first Paris Fair, with 486 exhibitors, which was held for 11 days in 1904, and every succeeding year till 1913, when none took place. It was subsequently decided to enlarge its scope and to give it a national character; and when the tenth fair, with 1,700 exhibitors, was held in 1917, the support of thirty-six Chambers of Commerce, 140 trade associations, besides that of the Paris Municipality, of the Department of the Seine, and of the Ministry of Commerce, had been obtained. After an interruption in 1918, it has taken place every year since 1919; and the Fair Committee, which receives financial aid from the Paris authorities and the Paris Chamber of Commerce, has further developed its scope as an exhibition of a considerable proportion of French industry, whilst retaining its strictly national and business character. In 1924 it gave, however, a first sign of becoming international; Belgian exhibitors were admitted and formed a separate group within each section of the Fair. Many principal industries, especially those of the Paris area, are regularly represented now in strength, such as the machinery, machine tool, electrical, building, jewellery, toys, articles de Paris, dressmaking, food and drink, furniture, printing, etc., trades; in 1923 two innovations were introduced, an important exhibit of the various wine-growing regions, and one of music, in two halls named Salon des vins de France and Salon de la Musique; in 1924 innovations were a foodstuffs section and a display of raw materials and native manufactures from French colonies (such as woods, wool, kapok, carpets, watches, etc.). The number of exhibitors, which in 1923 was 4,917 and in 1922, 4,500, was 5,200 in 1924.

The second modern French fair took place in Lyons in 1916; it was created as an international fair, and its aim has been to develop into a great annual international fair that would rival the Leipzig Fair. It was decided in 1923 to suppress the autumn fair (which had been mainly composed of metal, machinery and machine tool exhibits) and to replace it by an exhibition for a special branch of industry; a timber exhibition was held in 1923. The range of exhibits of the Lyons Spring Fair is great, including silks and other textiles, clothing articles, leather, furniture, jewellery, agricultural machinery, machinery and machine tools, electrical engineering products, motor cars, etc. Several foreign countries are regularly represented at Lyons.

The third annual fair, that of Bordeaux, inaugurated in 1916 and since held in May or June every year (except in 1918), is an international fair with a strong colonial tendency, the most important French colonies exhibiting native raw materials; but it also contains considerable exhibits of agricultural machinery, foods, drinks, etc.

In addition to these three annual exhibitions with their distinctive features held in three large cities, annual fairs of a more restricted scope, but not confined to single trades, although of especial appeal to agricultural interests, have been even more recently established at Tours (1921), Rennes (1922), and Niort (1923). An annual two or three monthly exhibition of a novel character was also established in 1921 in Paris, entitled Salon du Goût Français, in which the principal exhibits consist of jewellery, laces, dress, motor-cars, furniture and artistic products of various kinds, the objects being presented by means of lighted coloured transparencies. One-time events have also been numerous in the last few years; in 1922 at Marseilles (colonial exhibition on a large scale); in 1923 at Le Mans, Bayonne, Montpellier, Strasbourg, Orleans, Angers and Toulouse.

In Paris are held more or less every year a multitude of large exhibitions that are not of a general character, but are confined to special trades or groups of trades ; such as those relating to agricultural machinery ; to heating apparatus (in 1920 and 1921) ; to the motor vehicle and cycle trades ; to aviation ; animals (separate cattle, horse and poultry exhibitions) ; to horticulture (several in the year) ; to pictures, sculpture, furniture (three large-scale exhibitions, each lasting from six weeks to three months, as well as numberless minor exhibitions, are held annually); in September, 1923, a Foundry Exhibition was held in Paris, and in November, 1923, a large national exhibition of physics and of wireless telegraphy, which included also electric apparatus of many kinds, optical instruments, etc., achieved great success. Similar special exhibitions were held in 1921 at Nancy (Combustibles Exhibition), in 1923 at Dijon (food-stuffs), at Boulogne (fish) and at Digne (perfumery) yearly since 1921. An international sports goods exhibition was held in Paris in 1924 in connexion with the Olympic games.

The International Exhibition of Modern Decorative and Industrial Art is of considerable importance, some 30 nations taking part officially. The Exhibition which is being held in Paris this year (April-October) aims at the concentration of an extensive survey of the application of new ideas, not only to objects seeking primarily artistic quality, but also to those serving the ordinary purposes of everyday life and work. The following statement of the broad classification adopted indicates its scope : (1) architecture, including stone, wood, metal, ceramics and glass ; (2) furniture, including art and industry of wood, leather, metal, ceramics, textiles, books, toys, musical instruments, scientific apparatus ; (3) dress, including perfumes, flowers, jewellery ; (4) arts of the theatre, streets, and garden ; (5) education, including stone, wood, textile, glass, etc., work.

Another important International Exhibition, viz., the International Colonial Exhibition, is projected to be held in Paris in 1927. It appears probable, however, that this will be postponed until 1928 or 1930. The City of Paris has undertaken to contribute to its cost a sum equal to that granted by the French State, but not exceeding 50 million francs. It would appear that the scheme is on a large scale and that the range of exhibits includes all commodities that are received by the mother countries from their colonies, and all those that are despatched from the former to the latter.

Despite the multitude of fairs and exhibitions, unbroken success, as measured by the financial results of the undertakings themselves and by the crowds that flocked thereto, appears to have attended them in recent years, especially those in the capital. This success is due to many causes ; to the elimination of the mediocre attractions which tended to reduce commercial manifestations to the level of the survivals of those fairs of ancient date which had in part degenerated into popular amusements agglomerations ; to the keen intellectual and business curiosity, not only of the French industrial and commercial classes, but also of the rank and file within these classes ever on the watch for new ideas ; to the exceptionally attractive and central sites (*e.g.*, in Paris, Lyons, Bordeaux) ; to the splendid and admirably arranged exhibition halls or palaces ; to the care given to the arrangement of the exhibits and to the decoration of the setting ; to the choice of seasons for the particular exhibition ; to the great influx of visitors from many countries at various seasons into Paris, who, no doubt, contributed much towards swelling the attendance and the receipts (in those cases when entrance was not free).

ABROAD.—For the last generation — since the Paris Exhibition of 1889 — the suitable representation of France at foreign exhibitions has been safeguarded by the organisation entitled the Foreign Exhibitions Committee ; and in 1922 was formed the Foreign Fairs and Sample Exhibitions Committee, a body on a more permanent and broader basis, having as regular agents abroad the French commercial attachés and other Government representatives and, at home the offices of the regional groups of chambers of commerce. The Committee has its headquarters at the French Department of Overseas Trade. Its function is to prepare and organise French participation in foreign fairs by securing the co-operation of manufacturers and merchants as exhibitors, by arranging for suitable collections of samples for samples exhibitions, by centralising information, and by facilitating the installation of the exhibitions and fairs.

During recent years France has seized many opportunities for trade propaganda by this method; she has not only taken part in international exhibitions, but has also co-operated with certain foreign towns in organising exhibitions in which French goods were markedly prominent, has sent propaganda ships round the world, and has delegated ministers to be present at foreign exhibitions. In 1923, two French cruisers were commissioned to carry French samples exhibitions to (among other places) Australia, New Zealand, Japan, China, Straits Settlements, India, Ceylon and Egypt; and in a previous year an important mission to several States of South America included representation of economic interests. In 1921 a special train of thirteen Pullman cars carrying French exhibits traversed Canada at the invitation of the Canadian Government; at the halting places the exhibits were exposed, cinematographic displays of a propaganda nature were given, and the tour was concluded by a two months' exhibition at Montreal; in July, 1923, a travelling Canadian Exhibition contained in thirty large exhibiting lorries paid a return visit at the invitation of the French Government, visited the most remote parts of France, and concluded by a six weeks' display at the Tuileries. As regards support by Ministries of State, the French Minister of Commerce attended the Milan Fair in 1923, when he inaugurated the French pavilion, and the Copenhagen Exhibition in the same year; and in 1924 the Milan Fair. In March, 1924, when wireless installations were permitted in Spain for private persons, there was held in Madrid, under the auspices of the French Overseas Trade Department, an exhibition of wireless apparatus. The commercial offices maintained by the French Government in several countries (*e.g.*, Italy, England, United States, Switzerland) are permanently designed to serve as sample exhibitions on a small scale of French goods.

France took first place among foreign exhibiting countries at the Lwow (Lemberg) Fair in 1923, having had 88 exhibitors (45 in 1922 and three in 1921), and much business is reported to have resulted. She was the leading foreign exhibitor at the Zagreb Fair in 1924; the number of French firms was double that of 1923. French interests were also well represented at the Kiew and Nijni Novgorod Fairs in 1923, and at recent fairs at Prague, Vienna, Gothenburg, Luxembourg, and Ghent.

Beyond Europe, France was a very important participator in the Brazilian Centenary Exhibition at Rio de Janeiro in 1922-23, the State grant having been over 5,000,000 francs. A French fair was organised at Tientsin in 1923. In 1924 an important exhibition of French products was held at New York with the assistance of the French Overseas Trade Department and of a Franco-American group in the United States, who formed a company for the purpose; over 300 French firms exhibited.

It will be gathered from the foregoing that French efforts to promote trade abroad by means of exhibitions are constant and considerable. The State is supporting them financially, and otherwise is also in a position to supply many choice and magnificent objects from its own collections (such as Gobelins tapestries, Aubusson or Savonnerie rugs, Sèvres porcelain), which assist in conferring dignity and beauty upon French exhibitions abroad.

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FRIDAY, JULY 24, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, JULY 27th, at 4.30 p.m. (Dominions and Colonies Section.) PROFESSOR W. A. PARKS, Ph.D., President, Royal Society of Canada; President, Geological Section, British Association, 1925. SIR RICHARD REDMAYNE, K.C.B., M.C., M.Inst.C.E., M.I.M.E., M.I.M.M., F.G.S., will preside. Tea and coffee will be served in the Library from 3.45 p.m.

COUNCIL.

A meeting of the Council was held on Monday, July 13th. Present:—Sir Frank Warner, K.B.E., in the Chair; Mr. Llewelyn B. Atkinson, M.I.E.E.; Sir Charles S. Bayley, G.C.I.E., K.C.S.I.; Mr. P. M. Evans, LL.D.; Rear-Admiral James de C. Hamilton, M.V.O.; Sir Humphrey Leggett, D.S.O., R.E.; Sir George Sutton, Bt.; Mr. Carmichael Thomas; Professor J. M. Thomson, F.R.S.; and Dr. J. A. Voelcker, with Mr. G. K. Menzies, M.A. (Secretary of the Society) and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., was elected Chairman of the Council for the ensuing year.

The Hon. Sir Charles A. Parsons, K.C.B., LL.D., D.Sc., F.R.S., was elected a Vice-President of the Society, in place of Viscount Cowdray, G.C.V.O., who was unable to act.

The report of the Judges of the essays submitted for the Peter Le Neve Foster Prize was approved (see below).

It was reported that the judging of the works submitted in the second Annual Competition of Industrial Designs was proceeding at the Victoria and Albert Museum, and that an exhibition of the selected works would be held there from August 1st-31st.

The various Committees were re-appointed.

The Secretary was authorised to issue the Examination Syllabus for 1926 as soon as it should be ready.

Arrangements for papers and lectures to be delivered in 1925-26 were considered.

Other formal business was transacted.

PETER LE NEVE FOSTER PRIZE.

Under the Peter Le Neve Foster Trust the Council offered a Prize of £25 for an essay on "The Effect of Trade Union Regulations on Industrial Output." The judges were:—The Rt. Hon. Lord Askwith, K.C.B., K.C., D.C.L., The Rt. Hon. George N. Barnes, C.H., and Mr. W. L. Hichens.

Thirty-six essays were submitted. After a preliminary investigation the judges reserved thirteen of these for further consideration, and all of these were read by all the judges, who unanimously awarded the prize to Mr. C. G. L. Du Cann, Barrister-at-Law.

PROCEEDINGS OF THE SOCIETY.

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THIRTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 4TH, 1925.

SIR HERBERT JACKSON, K.B.E., F.R.S., in the Chair.

The paper read was:—

THE MODERN PRODUCTION OF SHEET GLASS.

BY PROFESSOR W. E. S. TURNER.

The account given in this lecture is that rather of an intelligent observer who has been privileged to follow developments in the past few years rather than of the expert acquainted with all the details of manufacture of some one process.

The production of sheet glass in its various forms of window glass, plate glass, figured and ribbed sheet, wired glass, indeed, in all the forms of so-called constructional glass, has to-day attained enormous proportions. We can gather something of the growth of the industry from the statistics which follow.

The data collected in America are far more complete than those in this or other European countries, and will satisfactorily serve our purpose, especially as the United States is easily the greatest consumer of sheet glass.

The two following tables, namely, Tables I and II analyse the statistics of domestic production, and of importation:—

TABLE I.

Production of Building Glass in the United States.

	1909.	1914.	1919.	1921.
	Thousands of sq. ft. and thousands of dollars.			
Window Glass—				
Square feet	346,081	400,999	368,912	260,065
Value	$11,743	$17,496	$41,101	$24,026
Obscured glass, including cathedral and sky light—				
Square feet	22,816	43,040	33,822	20,902
Value	$1,359	$2,417	$4,300	$2,547
Plate glass, total cast—				
Square feet	60,106	75,770	72,849	79,966
Polished, square feet	47,370	60,384	56,824	56,239
Value	$12,205	$14,774	$33,348	$37,261
Rough, made for sale as such—				
Square feet	206	131	789	712
Value	$37	$26	$171	$107
Wire glass, polished—				
Square feet	*	1,708	1,229	4,485
Value	*	$534	$654	$1,512
Rough, made for sale as such—				
Square feet	*	13,981	14,462	11,675
Value	*	$1,057	$2,271	$1,804
Other building glass, value	$965	$520	$1,886	$1,694
Total building glass, value	$26,308	$36,824	$83,713	$68,951
Total value of all glass produced	$92,095	$123,085	$261,884	$213,471

* Not available.

TABLE II.

Imports of Plate Glass and Cylinder, Crown and Common Window Glass into the United States.

(in thousands of square feet.)

Plate Glass.	1909-13 (5 yr. avge.)	1919	1920	1921	1922	1923
Belgium	2,013	—	1,445	2,123	7,489	†
Canada	*	4	272	554	407	†
Czechoslovakia	—	—	*	2	500	†
France	87	—	1	92	134	†
Germany	209	—	384	183	2,100	†
Netherlands	121	—	318	99	120	†

United Kingdom ..	35	—	16	1	21	†
Other Countries ..	‡1	—	§134	53	26	†
Total: thousands of sq. ft.	2,466	4	2,570	3,107	10,797	26,260
Total: thousands of dollars	$563	$3	$2,271	$2,070	$5,090	$16,047
Window Glass.		(in thousands of pounds.)				
Belgium	22,395	287	5,357	45,411	49,835	†
Canada	2	1	12	167	16	†
Czechoslovakia ..	—	—	25	138	290	†
France	87	7	9	37	614	†
Germany	711	129	352	467	810	†
Japan	1	226	¶	—	—	†
Netherlands	7	33	45	1,031	6	†
United Kingdom ..	2,615	350	427	824	1,280	†
Other countries ..	16	1	X1	31	—	†
Total: thousands of lbs.	25,834	1,034	6,228	48,136	52,851	46,661
Total: thousands of dollars	$889	$138	$624	$2,639	$2,583	$2,120

* Less than 500 square feet.

† Figures for distribution of exports by countries not available for 1923.

‡ Including imports from Canada.

§ Including imports from Czechoslovakia.

¶ Less than 500 pounds.

X Including imports from Japan.

Table III contains figures of exports and imports of the United Kingdom for plate, window, and other sheet glass, and will give some idea of the growing importance of the industry in this country.

TABLE III.

UNITED KINGDOM—EXPORTS AND IMPORTS.

PLATE, SHEET AND WINDOW GLASS.

Year.	Exports. Cwt.	Imports. Cwt.
1901	66,835	1,712,494
1905	118,011	1,654,598
1910	231,866	1,519,039
1915	140,771	1,042,986
1920	515,018	731,965
1921	354,663	586,128
1922	546,075	870,661
1923	742,995	862,095
1924	789,267	953,896

It will be gathered from the foregoing tables that in Europe, Belgium, Germany, and Great Britain are countries exporting sheet glass in quantity; with Belgium holding first place.

THE COMPOSITION OF SHEET GLASS.

For many years, until recently, the composition of the glass used for sheet, whether blown or rolled, had undergone practically no change. There was in general use a glass having the composition approximately: silica 72-74 per cent., calcium oxide 12-14 per cent., and sodium oxide 12-14 per cent. In two of the automatic processes recently introduced, however, a softer glass has been employed, the percentage of sodium oxide having been increased Table IV states the composition of some samples of sheet glass, the values recorded for the sample of Ford plate being calculated from the batch composition on the assumption that all the saltcake was decomposed, the others being the results of analysis.

TABLE IV.

COMPOSITION OF SOME SAMPLES OF SHEET GLASS.

Type.	SiO_2	As_2O_3	Al^2O_3	Fe_2O_3	MnO	CaO	MgO	Na^2O	SO_3	Total
Window, hand blown...	72.68	—	1.06		—	12,76	0.26	13.24	—	100.00
,, Libbey-Owens	72.14	—	1.96	0.15	0.01	11.24	2.62	12.60	—	99.81
,, Fourcault	70.64	—	0.77	0.11	trace	10.58	0.09	17.02	0.78	99.99
Plate, ordinary cast ...	72.40	—	0.51	0.09	—	13.74	0.12	12.82	0.28	99.96

The introduction of magnesia to the extent of about one-fourth to one-fifth of the total lime and magnesia tends to make more uniform the rate of change of viscosity than when lime alone is present, whilst devitrification tendencies are retarded. In America, the use of dolomitic lime is widespread also for another reason, namely, the lower iron oxide content than in ordinary limestone.

The source of sodium oxide was, until comparatively recently, saltcake or sodium sulphate. A small and variable amount of this, up to a maximum of about 0.7% SO_3 remains undecomposed, and is probably the cause of the more favourable working qualities which glass made with saltcake as a batch constituent is stated to possess. Nowadays, in order to speed up the rate of melting, soda ash supplies most of the sodium oxide. The following modern batch compositions may be of interest:—

AMERICAN WINDOW GLASS.

	Lubbers Cylinder Process.	Ford Plate Process.
Sand	1,000	1,000
Soda Ash	260	305

Saltcake	40-80	56
Limestone	350	260*
Coal or Charcoal	—	2.9
Arsenious oxide	—	3.5
Cullet	35-40%	360

*A magnesium limestone is used with CaO : MgO about 4 : 1.

METHODS OF MANUFACTURE.

In view of the title of this paper, it is desirable to define what is meant by the term "modern." The main object of the lecture is to direct attention to methods brought to success within the past ten years, and designed not only to produce sheet glass in great bulk by automatic mechanical methods, but also, particularly in the case of window glass, to improve its quality by removing the cause of distortion from which it has hitherto frequently suffered.

At the present time these mechanical methods by no means hold the field. Indeed, in this country, in Belgium, and other European countries much glass is still produced by hand, in which cylinders up to about 6ft. in length and about 12ins. in diameter are blown, subsequently opened by cutting the cylinder longitudinally, and flattening it out in a flattening oven.

I propose, however, to omit description of this process, but it is desirable to include some account of a mechanical method which developed out of it, because the method is really modern and is in extensive use. This process is due to the experiments of J. H. Lubbers, a window glass flattener of Pittsburgh, U.S.A., who began experiments in 1894—experiments which were first commercially successful in 1905.

In this system the glass is melted in a large tank which may be of considerable size, one seen by the author having a dead weight capacity of nearly 2,000 tons. The cylinder made by the Lubbers process may be drawn either from one or more of a series of wells or pits attached to the refining end of the tank furnace, or, a more usual practice, from a shallow fireclay pot of approximate dimensions and shape to those shown in Fig. 1. This fireclay pot is a double one. It is suspended in such a way that after the cylinder has been drawn the pot can be inverted and a clean receptacle brought into use while the residual glass is slowly drained away from the section of the pot just used, a flame playing into the part assisting the process.

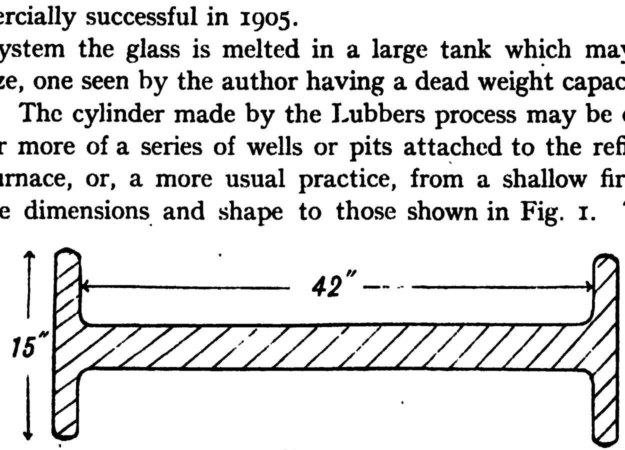

FIG. 1.

The initial stage consists in removing from the tank furnace by means of a huge iron ladle, suspended and swung from its centre, a charge of glass sufficient to complete the cylinder required. The charge on the average is about 560 to 570 lbs. of glass. This is poured into the drawing pot, the temperature of which has already been raised by gas burners playing into it, and after the glass has been added the temperature is again adjusted until it reaches a value of about 2,200° F. just before the drawing operation is begun.

A blowing-head is then lowered by means of a very long flexible steel tube until the lip is immersed below the glass surface. Various forms of blowing-head are used, varying slightly from works to works. Fig. 2 is a diagram of two actual shapes which have been employed. The glass flows into the head and forms a solid ring inside the rim of the blowing-head, serving to attach the cylinder to the head during the operation. As soon as the ring is formed the head is raised slowly by an operator who stands in an elevated box or cabin in full view of the cylinder. The cabin contains a number of switches and controls, enabling the rate of drawing to be varied, as also the pressure of air which is applied. For the major part of the drawing operation the air pressure is only a fraction of an inch. Fig. 3 is a diagram of the variation of air pressure throughout the operation. It will be noticed that the pressure reaches its highest value for a very short period while the cap is being formed, and after being diminished greatly is slowly increased towards the end of the drawing operation.

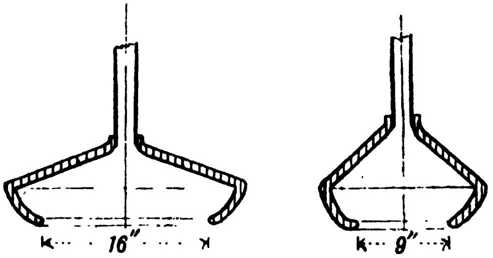

Fig. 2.

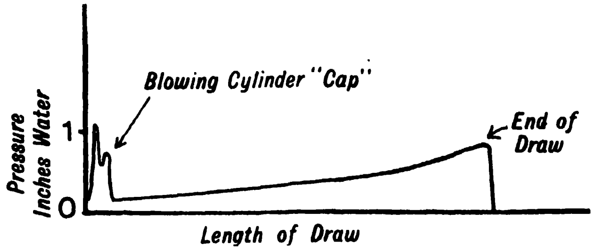

Fig. 3.

The time taken for drawing a cylinder varies somewhat, but 18 minutes may be taken as an average. The initial temperature at drawing may be about 2,190° F., and the final temperature 1,750° F. At the end of the drawing operation the rate of drawing is accelerated, and the air pressure increased so as to produce thin walls, and make it easy to detach the cylinder from the residual glass in the pot.

By this process cylinders of length as much as 36ft. after the removal of the ends, have been obtained. The diameter may be as much as 36ins., but is more usually 28 to 30ins.

Defects arising during the drawing operation are principally those due to stones, often due to fireclay. An attendant may be stationed near the cylinder to watch for these stones in the section of the cylinder as it leaves the pot, and by means of a stick he can thrust the stone into a pocket, where, on cooling, it will not set up cracks in the main portion of the cylinder (Fig. 4).

The tall cylinder is lowered into a horizontal position and placed on a horse, consisting of a series of wooden ribs in the curve of which the cylinder lies. The latter is divided into shorter cylinders by an operator who wraps round it a wire which is heated electrically. Each short length is then split by means of a red-hot iron rod, which is worked up and down the interior of the cylinder at the point of contact which it makes with the table on which it rests. In some factories the cylinder is cracked into two semi-circular portions; others a single crack is regarded as sufficient. The splitting of the cylinder and the conversion of the pieces to a flat sheet present no element of novelty. The process is that used with hand-made cylinders.

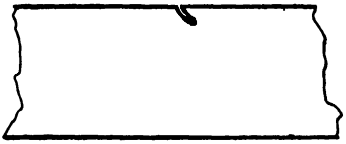

Fig. 4.

The flattening process is carried out on a stone of fireclay in the formatio of the upper portion of which fine grog has been employed, and the stone must be carefully polished and re-polished at intervals. The cylinder is introduced through a tunnel in which it may slowly be heated up, and if only one split has been made in the cylinder the latter is brought on to the flattening stone with the split uppermost. The flattening chamber is maintained at a temperature of 650 to 700° C., as the result of which the sheet softens and the cylinder opens, the sides of the cylinder falling under their own weight. An operator completes the flattening by means of a block of wood at the end of a long handle, beech wood or some other wood which contains a minimum percentage of ash being employed.

This process of Lubbers has been extensively used in America, and to some extent in England and in France.

THE METHODS OF DRAWING SHEET DIRECT.

Cylinder-drawn glass, however carefully prepared, must inevitably be liable to produce distortion since the inner and outer diameters are different. Attempts were made many years ago to draw sheet glass direct from the bath. For example, an Englishman, William Clark, as early as 1857 attempted this process, but his attempt, and many subsequent ones, failed because of the tendency of the sheet to tail off. In the present century, however, the difficulty has been overcome in two ways: by Emil Fourcault in Belgium and by Colburn in the United States. For convenience we will describe the Fourcault method first.

THE FOURCAULT SHEET GLASS PROCESS.

The success of this process depends on the use of a fireclay float known as a debiteuse (Fig. 5), the essential part of which is the slot. This slot is sunk below the level of the outer wall, and is wider at the middle than at the ends, a feature essential to the supply of glass to prevent the sheet tailing off.

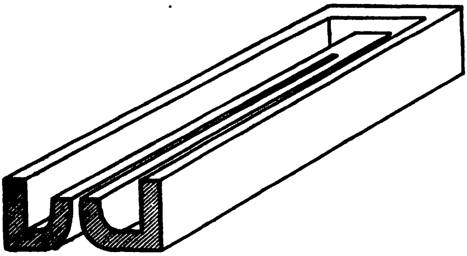

FIG. 5.

The debiteuse is sunk in the glass in a section of the furnace known as the drawing well, and the depression of the slot below the exterior walls causes glass to well up through its lips. A bait consisting of a sheet of glass can be let down to attach itself to the molten glass as it flows through the drawing slot, and once adhesion has been made the sheet may be raised, and becomes continuous.

The glass is melted in a large tank provided with a floating bridge and a brick curtain to screen it from the refining end of the furnace. From this refining end the glass flows through a short neck into a long crosspiece provided at intervals alternately with drawing pits and with gas ports, the latter to maintain the temperature of the glass at a suitable level. The glass in each reheated section is separated from that in each drawing pit by means of a shallow bridge dipping about 2ins. below the glass level, and thus serving as a skimmer for any impurities.

Above each drawing pit a chamber is built, up which the sheet is drawn vertically as indicated in Fig. 6, the drawing being carried out by a series of pairs of rollers covered with an asbestos composition. The exit from the

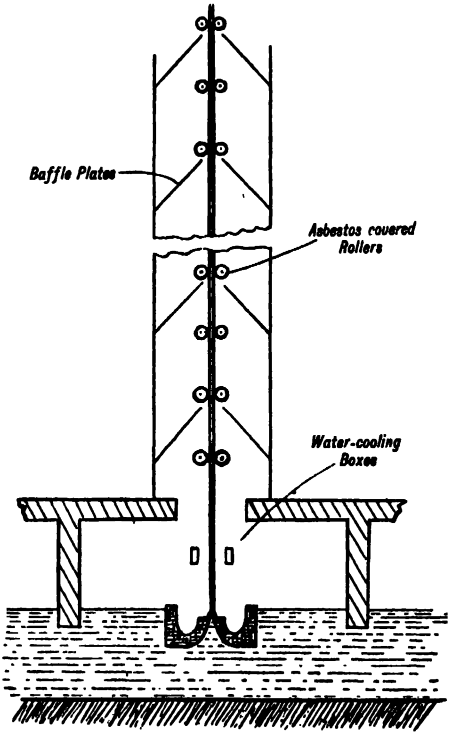

Fig. 6.

vertical chamber which leads direct into the cutting rooms is only 18 to 22 ft. above the level of the glass in the drawing pit, so that arrangements have to be made for a very rigid control of the temperature. The temperature in the drawing pit is regulated so as to be about 1,040° C. This temperature can be regulated readily so long as the machines remain in continuous operation, since they will continue to draw glass at a steady rate from the tank, and the temperature will be maintained. Should a drawing machine break down it is necessary to put on an auxiliary burner to maintain the temperature in the drawing pit itself.

The next important point is that the temperature of the sheet of glass shall be slightly below the critical annealing temperature (say, 550° C.) just before coming into contact with the rollers. As the first pair of rollers may be no more than about 2ft. 6ins. above the glass surface, cooling has to be arranged by iron boxes placed just above the drawing slot parallel to the sheet. By this means the temperature just above the drawing slot is reduced to about 750°.

Between the first pair of rollers and the exit into the cutting room the temperature falls from about 550° C. to 60° C., and in this short length of approximately 20ft. the annealing is carried out. The rate of drawing of glass of double strength is about 26 metres per hour, and of single strength

40 metres per hour, so that no point of the glass remains in the chamber longer than about nine to fifteen minutes.

Of the two striking advantages which the Fourcault possesses over other methods, that of rapid annealing is one. The author has not found the amount of residual strain excessive in those pieces which have come into his possession. Very great economy is, therefore, effected, not only in the time of production but also in the cost of construction, since the long lehr of 200ft. used in the Libbey-Owens process is avoided. The other advantage lies in the number of drawing machines which can be operated on one furnace. Eight machines, four on each arm of the T, have been operated, and in the British works as many as 14 machines were erected for a single furnace.

The productivity of each machine at single strength is rated at about 25,000 square metres per month of 30 days.

Very much progress has been made with this process since the war. The early patents were taken out between 1901 and 1903, and a company was formed in Belgium in 1904 to exploit it, but even in 1914 it was still far from being commercially successful. Since that date, however, the process has been adopted at several factories in Belgium, and other plants have been erected in Czechoslovakia, England, France, Holland, Greece, Germany, Italy, China and Japan, whilst it has extended, also, to four operating factories in America, with other plants under construction.

THE LIBBEY-OWENS PROCESS.

The idea of this process occurred to the inventor, I. W. Colburn, in 1905, after witnessing a paper-making machine, and from that date until 1912 he was engaged in an attempt to commercialise the process. More than one million dollars were spent in this stage of the operations, and, funds having been entirely exhausted, the Company which Colburn had formed was sold up, and the patents bought by the Libbey Glass Company at the instigation of Mr. M. J. Owens. The process is now generally known as the Libbey-Owens process. Six years of further experiment were necessary before glass for sale was produced in 1918 at the special factory erected at Charleston, West Virginia, although the experiments between 1912 and 1916, conducted at Toledo, indicated that the process was certain of ultimate success.

The difficulty of the tapering sheet is overcome in this process by the use of two knurled or cogged rollers which operate just inside the trough from which the sheet is drawn, and by clutching the edges maintain the width of the sheet constant.

Fig. 7 will serve to indicate the essential features of the process. The details of the plant at the present time differ very slightly from those shown in the diagram.

The glass is melted in a large tank furnace and passes through the refining end into a fireclay trough from which it is drawn. The temperature of the

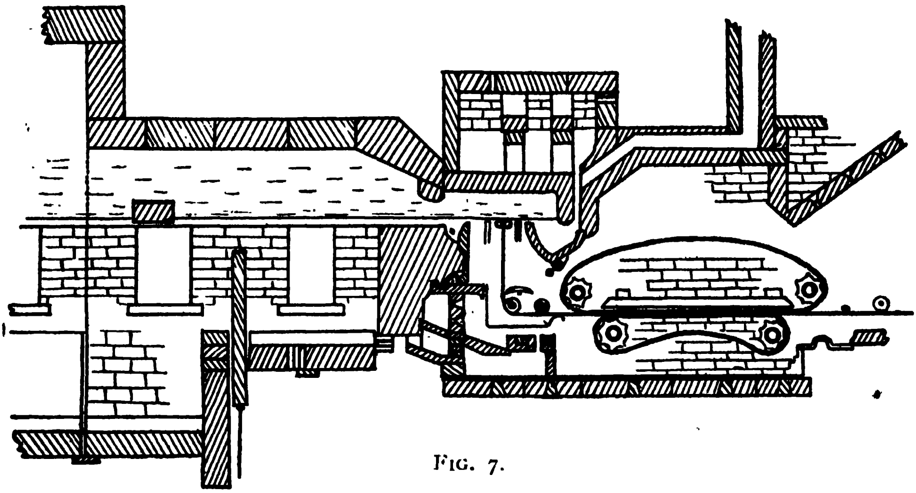

FIG. 7.

glass in the trough is regulated by a gas flame which heats the trough from below, and by auxiliary burners which may be applied to the glass surface.

In order to start the drawing operation a bait is employed consisting of a flat iron bar 6ft. long and 3ins. wide, attached to flexible metal strips. This bar is let down over the bending roller until it comes into contact with the glass in the trough, and as soon as the glass grips the bait it is drawn in a vertical direction until it reaches the bending roller, after which it takes a horizontal direction. The sheet is moved forward by the agency of the two pairs of knurled rollers just above the glass level, and the pair of endless belt tractors applied to the sheet immediately beyond the bending rollers. The bait is cracked off when it reaches the flattening table, which is about 10ft. from the bending roller, and the sheet then moves forward on a series of 200 asbestos-covered rollers along the annealing lehr, which is 200ft. in length, and heated with gas burners so spaced as to give the necessary temperature gradient to produce satisfactory annealing. The temperature in the lehr is controlled by a series of thermo-couple pyrometers.

The knurled rollers which grip the sheet as it is drawn from the trough are water cooled, and a water cooling device stretches across the drawing trough on both sides the sheet as it emerges from the trough. This cooling is for the purpose of causing the glass to set. The speed of the knurled rollers plays an important part in the production of a good sheet, and it has been found of advantage to rotate these rollers at a peripheral speed slightly less than that with which the sheet passes over the drawing table.

Since the sheet has been cooled to cause it to set, it is necessary to heat it somewhat by the application of burners immediately before it passes over the first roller. This first roller is the actual bending roller, the second one of similar dimensions being an idler roller. The condition and control of this bending roller is very important. It is made of a non-corrodible alloy, nichrome, having given best results out of the nine or ten special alloys tested. The roller is 6ins. in external diameter, and has a wall of 1in. thickness. Both the bending roller and the idler roller are air cooled, the extent of cooling being regulated by the operator; the temperature maintained is such that at night they can be seen to be barely a dull red. If the roller becomes too hot the sheet begins to stick to it, whilst if it is too cold the sheet becomes checked.

The limits of thickness of the sheets drawn by the machine are 1/24in. and 5/16in., the rate of drawing varying from 100ins. to 25ins. per minute. Each drawing machine has a capacity rated at 500 to 550 boxes of single strength glass per 24 hours, and in the majority of the plants erected in the last three or four years two drawing machines have been constructed to each melting tank, the latter being situated in the middle, thus feeding glass to drawing troughs situated at each extremity.

The West Virginia plant at Charleston now has a capacity for producing 150 million square feet of single thickness sheet per annum. Two other small plants have been erected in America, and the process has spread to Europe and other countries. The parent European plant, which at one time it was hoped would be located in this country, was ultimately established at Moll, in Belgium. A factory is now in operation in Switzerland, and others are under construction in France, Spain, and Italy. Japan, also, has one of these plants, and so, also, has Canada, although the factory in Canada is not at present in operation.

THE FORD PLATE-GLASS PROCESS.

The process of making plate glass in general use at the present day originated in the invention of Thévart in 1665, a process which was developed at the famous St. Gobain works. Since that date the method has remained practically unchanged, although in recent years attention to the detail of furnaces, casting tables, lehrs, etc., and especially to developments in grinding and polishing, have resulted in considerable increase in the output. The method entails melting the glass in pots, removal of the pot and glass from the furnace and its transfer to the casting table by means of a crane, the casting of the glass on a large iron table in front of a heavy roller, which then traverses the table from end to end, rolling out the glass into a sheet. The latter is then pushed forward into the first chamber of a long lehr, from the end of which it ultimately emerges to be cut up, set on a grinding table, and after being ground must again be set in pieces on a polishing table for the final treatment.

The tendency of all factory operation to-day is towards continuous operations. The Libbey-Owens and the Fourcault processes produce flat sheet in a continuous broad ribbon, which only needs to be cut up into suitable pieces by the glass cutter, whilst in the cylinder process, the cylinder must first be produced, and then separately cut into lengths, opened out, reheated, flattened and annealed.

In the case of plate-glass production the continuous rolling of pieces of great width 12 or more feet, the size of the average casting table, is by no means an easy operation. The width of the sheet required for motor car wind screens being of comparatively small dimensions has made it possible to begin a continuous process of plate glass manufacture.

The enormous demand for plate-glass in America, both for constructional purposes and for motor cars, and the consequent difficulty of obtaining supplies led Ford to a decision to make his own glass. His first step was to purchase the Allegheny Plate Glass Co., near Pittsburgh, and as this source of supply was still quite inadequate to meet his demands, he had experiments set on foot at his Highland Park Works, Detroit, with the view to making plate-glass continuously. The result was the establishment on the site of the River Rouge Works of a new glass works comprising four units, each unit a tank furnace feeding glass continuously to a pair of rollers, annealing lehrs, and continuously operating, grinding and polishing plant, in addition to maintaining the single experimental unit at Highland Park.

In the Ford process, the glass, instead of being melted in a pot, is produced in a tank furnace 40 x 20 ft. at the melting end, 16 x 20 ft. at the refining end, with a depth of 5ft. The heating of the furnace, as also the subsidiary heating operations are carried out by coke oven gas of 530 B.T.U. made at the River Rouge plant. The cost of this gas is 25 cents per 1,000 cubic feet. At the Highland Park plant coke oven gas is not available, and producer gas of average B.T.U. 150 to 160 is employed at a cost of 9 cents per 1,000 cubic feet.*

The refining end of the tank tapers to a nose of six feet radius, and to it is attached a rectangular fireclay spout or channel, like the boot of the feeding devices now so much in use in feeding glass bottle machines. The end of the channel adjacent to the furnace has an adjustable fireclay gate which can be raised or lowered to control the rate or outflow of the glass. The end of the spout, about 12in. wide, from which the glass flows, is itself 10ins. below the level of the glass in the tank. The glass falls from the spout into the angle between two water cooled rollers, the upper one 9ins. diameter, and the lower 48ins. Gas burners on three sides of the spout are directed on to the glass, as it flows from the spout between the rollers, in order to maintain the glass fluid for rolling.

The rollers are cooled with water, the rate of flow of which is controlled very precisely so as to maintain the outflowing water at a temperature of 180° F.

The sheet, 40ins, wide, issues at a slight inclination from between the rollers and passes on to an endless belt into the lehr, which is about 440ft. long, and has a series of gas burners at intervals to give the necessary temperature gradient. The initial temperature of the lehr is 1,150° F., and the lower critical annealing temperature is stated to be 750° F. A series of 15 thermo couples are used for the temperature control in the lehr itself. Any one point in the rolled sheet passes through the lehr in two hours forty minutes. Sample strips are cut from the edge every two hours for examination with the view to ascertaining the success of the operation.

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* August, 1924, rates.

At the end of the lehr the glass is cut into lengths, and set on a grinding table which is operated continuously, the pieces being bedded in Plaster of Paris on a continuously moving table. The grinding table, which is approximately the length of the lehr and is parallel to it, consists of two arms united by a turntable. From the beginning of the table the glass is carried under a series of 42 rotating grinders down the centre of which the grinding material is fed by means of a pipe. The grinding is first carried out by coarse sand followed by finer sand, and then in successive stages by garnet of different gradings. In regard to the sand, a rounded grain sand is preferred, since it does not produce deep scratches, and sand from Lake Erie is found to be suitable for the purpose. Very much care is given to the control of the size of the grains of garnet. The material which flows away from the table is recovered and graded in settling tanks, and re-used.

After the grinding operation the sheets pass to a point on the table at which they may be readjusted before passing on under a series of 35 polishing wheels which are fed intermittently with small quantities of rouge and water. At the turntable, which is arrived at after the sheet has passed under the polishers, the sheets are turned over and reset, and sent forward on the return journey down the second arm of the table, where the second face of the sheet is first ground and then polished.

The rate at which the glass travels down the table is about 30in. per minute.

On the day prior to the writer's visit, the loss on the three separate eight hours' shifts had ranged from 67 to 94 sheets out of a total production per shift of 350 sheets. Some of the damaged sheets were salvaged by cutting them to smaller special sizes.

During the early days of the process the loss had been as high as 50 per cent., the main faults arising during the annealing and through grinding sleeks. Emery had been used instead of garnet initially, but after replacement by garnet the loss by scratching had been reduced to less than 1 per cent.

The smoothness with which the whole plant appeared to operate was very striking.

One considerable advantage of this continuous process is that the thickness of the sheet as rolled can be adjusted so as to reduce the amount of grinding necessary to a comparatively small amount. In plate-glass cast by the ordinary process the surfaces may be very rough, due to the roller on the upper surface, and on the lower surface to the sand spread over the casting table to prevent adherence. In the rolled sheet made by the Ford process only faint dapples were to be seen, whilst the thickness of the sheet produced from the double roller was about 3/10 of an inch.

It may be remarked that attempts to operate continuous systems of plate-glass production are now being made in a number of works, and this country is not lagging behind in the race.

The author would like to express his thanks to Messrs. British Window Glass Co., Ltd., for specimens, and to Mr. A. Cecil Pilkington for specimen models and a number of lantern slides with which the lecture was illustrated.

DISCUSSION.

The Chairman, in opening the discussion, said he thought the audience would agree that they had listened to an extremely interesting story. The subject was a fascinating one, and it was a remarkable example of how quickly changes could take place. Not so very many years ago the manufacture of plate-glass by a continuous process was impossible; indeed, might have been considered unrealisable, yet it was going on at the present day.

Mr. E. A. Coad-Pryor, after thanking Professor Turner for his very lucid explanation of the processes of sheet-glass manufacture, said he would like to ask how far the window-glass industry had hit the plate-glass industry. One would imagine that there was not much competition between the two sections, but the plate-glass people must have considerable difficulty in getting rid of the smaller pieces of glass which necessarily resulted from their operations, and they must be hard put to it to dispose of those pieces. One point about the continuous manufacture of plate-glass was that one would imagine in such a process, judging from other flow processes in glass, that stringy and cordy glass must be rather common, and it would be interesting to know if Professor Turner had any information on that point. Perhaps it was a fact that stringy and cordy glass was common in the process and was rejected in large quantities. He would also like to ask Professor Turner if he had any information as to the tolerances in temperature which the Fourcault and the Libbey-Owens processes demanded. One would imagine that in those flow machines, knowing how very quickly the viscosity of glass changed with comparatively small differences in temperature, the tolerance must be very small. When dealing with such a very large quantity of glass as 1,000 tons, one could imagine that the glass began to drop in temperature before one realised that the temperature was dropping; when dealing with tons of glass and the temperature went down it was not very easy to get it up again, and one could imagine that there were difficulties in that respect.

Mr. Walter C. Hancock, dealing with the question of the manufacture of glass by continuous processes, said that those who, in the early days, had looked through a good many patents would be struck by the great amount of success which had followed the very numerous and what must have been the very costly attempts to perfect those processes. One thing which had struck him in the Fourcault process was the shallow depth in the float, which seemed to have solved the great difficulty of adjusting the thickness of the sheet in order to make it drawable. There was one question he would like to put to Professor Turner. It had long been recognised that the hand-production of glass must necessarily involve very costly labour. There used to be an old saying that it took three generations to make a glass-blower, and it would be interesting if Professor Turner could give any figures with regard to the cost of labour—not only the number of men required for the production of a given number of feet of glass, but also as to whether the present labour was less skilled than in the old hand-processes, and whether that had introduced any change in cost. It seemed a little surprising that Mr. Ford should have introduced a process of making sheets continuously in large sizes when, comparatively speaking, he must use a large number of pieces of comparatively small dimensions.

Mr. A. Saxton asked if Professor Turner had formed any opinion as to the quality of the glass manufactured by the Fourcault process in comparison with the hand-process. Professor Turner had mentioned in connexion with the Fourcault process that the time of annealing never exceeded seven minutes. That hardly fitted in with the drawings of the various thicknesses, because so far as he himself remembered, when one was drawing four millimetre glass the speed of drawing was roughly about 14 inches a minute.

Mr. H. G. Cameron mentioned that when he was in America in 1921 a number of German-American journals were advertising pretty extensively the application of plate-glass to ordinary dwelling houses. He understood that that type of glass had been largely adopted by wealthy Americans in their mansions. At that time he did not think the Ford process had developed to its present extent, and it seemed to him that the continuous process for the production of plate-glass should cheapen it. If there was an advantage in using plate-glass in dwelling houses he thought it would be universally adopted in preference to sheet-glass, because with plate-glass one got a clearer vision of the immediate surroundings.

Professor Turner, in reply, said he had been asked his opinion as to whether or not the new window glass processes had affected the plate-glass industry. He was afraid he had no information in regard to part of that question, but, undoubtedly, it was influencing it in this sense that a flatter glass—the more perfectly directly drawn sheet-glass—certainly approached more to plate-glass in general qualities (the absence of distortion, and so on) than the cylinder-made glass could hope to do. In that connexion there was an interesting development. Some of his hearers might conceivably have heard of Chance's Patent Plate. This was selected window-glass which was ground and polished. The Libbey-Owens Company had some months ago determined to begin competition with plate-glass. The principle on which it was to work was to draw thicker glass from its machines and to grind and polish it. At Toledo they had erected a very large grinding and polishing plant which was going to treat the glass made at the Charleston or other works. It was originally intended to put down a melting plant at Toledo, and that might come later.

As to the question whether stringy or cordy glass was common, the glass which was fed from a tank furnace certainly was not free from these defects. When he had been at the Ford plant he had not seen much evidence of cordiness or stringiness. That might have been his good fortune. In regard to the Libbey-Owens' plant, he knew they were troubled from time to time with strings and cords, because one of their staff had invented a stirring machine in the endeavour to get rid of them. However, from the figures which he had seen of the efficiency of production, it would seem that cords and strings were not a very vital factor. They existed, but they were of less importance than one would imagine. There was another reason why he thought that difficulty of cords and strings had been reduced to a minimum—in that the continuous glow process had been adopted by firms who already had a reputation for producing glass of very good quality.

With regard to tolerance in temperature, the question of temperature control was really a most important factor, both in the Fourcault process and in the Libbey-Owens' process. The audience would have gathered some idea from the diagrams what care had to be taken. In the case of the Fourcault process, control could be given at several stages, for example, at the neck which joined the main melting tank with the T-piece, and then the ports which were placed on both sides of the drawing pits. An auxiliary burner might also be employed. The difficulty of maintaining constant the temperature of a body of glass was one of the most important points which had been raised recently at a Conference at Geneva, where there had been an attempt to force factories to close down for a 24-hour period each week. It had been pointed out there that in their processes the Fourcault and the Libbey-Owens Companies might have such difficulties of control that to stop the operation for 24 hours would mean a very great deal of time lost in regaining control, largely because of the question of temperature limits.

Mr. Hancock had asked him a question about which he (Professor Turner) was supposed to know nothing. All he could say was that it was estimated—and he thought the figures applied also very roughly to the Libbey-Owens process—that the cost of drawing one metre of sheet-glass by the Fourcault process was, to the cost of production of a square metre of glass by the hand-making process, in the ratio of 5 to 7, that was to say that in the Fourcault process the cost was about 5/7th of the hand-made process.

Mr. Saxton had referred to the question of quality. That was really very difficult to judge unless one had very considerable experience of sheet-glass, and, personally, he did not pretend to be an expert. What one factory would call quality A, or first quality, very often would not meet the standards of another factory. In the cylinder and machine cylinder process the proportion of grade A—that was, the very first quality—might be 15 to 20 per cent. At least those were the figures of a very well-managed factory. In others they would run from 25 to 30 per cent., but that was unusual, he understood, for the very first quality. There were three qualities, as a rule, and of A it might be said there were 15 to 25 per cent. He understood in connexion with the Fourcault process one of the European plants was claiming that it was now producing something like 30 per cent. of Grade A and more than 90 per cent. actually of saleable glass, so that the actual loss was very small. That indicated how the difficulties of the process were being overcome and the quality rising. It was undoubtedly rising in the same way with the Libbey-Owens process.

With regard to annealing, he had not said seven, but 12 minutes. The time depended on the rate of drawing. The surprising thing was that the glass was annealed so well. It suggested that to make the annealing operation continuous with the production, led to both easier and more complete annealing, just as in the process now being introduced for bottle glass in which the bottles as they emerged from the machine passed straight away into the lehr without any cooling off resulted in almost strain-free glassware. Prevention from contact with the air, preventing thereby the formation of skin, might be of very great value in reducing the time and in increasing the thoroughness of the annealing process.

THE CHAIRMAN proposed a hearty vote of thanks to Professor Turner for his interesting account of his personal experiences in visiting large works.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

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FRIDAY, JULY 31, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICE.

COMPETITION OF INDUSTRIAL DESIGNS.

An Exhibition of selected works submitted at the Society's Annual Competition of Industrial Designs will be held, by the courtesy of the Director, in the North Court of the Victoria and Albert Museum, South Kensington, S.W., from Saturday, August 1st, to Monday, August 31st (both inclusive). The designs exhibited are divided into the following classes: Architectural Decoration, Textiles, Furniture, Book Production, Pottery and Glass, and Miscellaneous. The Exhibition will be open to the public free.

The Reports of the Judges, including the awards of travelling scholarships, medals and prizes, have now been received, and it is hoped to publish them in the *Journal* at an early date.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, MAY 8TH, 1925.

SIR REGINALD ARTHUR MANT, K.C.I.E., C.S.I., in the Chair.

THE CHAIRMAN, in introducing the reader of the paper, said that Sir Gilbert Walker, after a brilliant career at Cambridge, where he came out as Senior Wrangler, was elected a Fellow of Trinity and appointed mathematical tutor, so that he might have looked forward to spending the rest of his days in peaceful contemplation of the higher mathematics. But "some far-reaching Nemesis steered him" from his home on the banks of the Cam and he fell under the spell of that most coy and capricious of all mistresses, the weather. In 1902 he joined the Meteorological Department in India, and two years later was appointed Director-General. For upwards of twenty years he studied the habits of his wayward mistress and learned to anticipate her moods. His annual forecasts of the monsoon rains both winter and summer were always anxiously awaited, because the amount and distribution of rainfall in India affected the happiness of countless millions of people. He perfected a system of storm signals by which he saved many ships and their crews from destruction. In recent years the Air Force had learned to rely on his forecasts of the winds before setting out on raids and expeditions. It seemed strange that a man sitting in a secluded office in Simla should be able to keep his finger on the pulse of the spirits of the air, but that was what Sir Gilbert did, and he would ask him now to give the Society some idea as to how it was done.

The paper read was :—

THE METEOROLOGY OF INDIA.

By Sir Gilbert T. Walker, C.S.I., M.A., Sc.D., Ph.D., F.R.A.S., F.R.S.,
Professor of Meteorology, Imperial College of Science and Technology, and late Director of Indian Observatories.

The climate of India is of special interest, not merely as that of the greatest tropical region in the British Empire, but also because it seems to have been designed by nature with the object of demonstrating physical processes on a huge scale. The area involved includes the driest of deserts and the steamiest of swamps; part of it is in great measure isolated from external influence to the north by the most complete mountain barrier in the world, so that many of nature's experiments are not disturbed by interference from outside; and in Ladak, which is a western continuation of Tibet, we can observe minimum temperatures which are not only relatively, but actually, arctic.

The explanation of the great temperature differences lies in the extreme transparency of the air to heat radiated from the ground during the very dry winter periods. At the Punjab hill stations on clear nights in December the warmth of the ground radiates fast into space; and the air in contact with the ground is chilled, becomes heavy and runs away downhill, its place being taken by unchilled air at 38° or 40° F., of which there is an unlimited supply: so the temperature at the hill station cannot fall below about 38°. On the other hand, at Rawalpindi, at the foot of the hills, the air, after being chilled, can find no escape and the minimum of 37° so produced is, night after night, lower than that of the hill stations. If we want a low minimum at a high elevation, we must find a place like an air tank without an outlet: accordingly at Annandale, 800 feet below the Simla ridge, where the air is largely enclosed, the night temperature is about 18° lower than on the ridge. An obvious application of the principle was to use a low canvas screen to check the escape of air from the Simla skating rink; and while in the gentler frosts of early winter the ice was improved, the screen became unpopular in January, because the ice was too hard to be skated on with pleasure. Even in the daytime the chilling by radiation at Simla is so powerful that it is customary to flood the rink at 10.30 in the morning, for the water will be good ice for skating by 4.30 p.m., though the temperature in the shade four feet above the ice varies between 43° and 50° F. At Dras, in Ladak, the conditions in a broad valley at 10,000 feet are so favourable for radiation that 72 Fahrenheit degrees of frost are occasionally measured at our observatory. The familiar " cold weather line " of the Punjab hill stations marks the boundary over the plains between the chilled air below and the warmer air above; the evening's smoke and dust will rise through the cold air as soon as they are warm enough to do so, but on reaching the boundary these will be colder than the heated and light air above the boundary; further ascent will be impossible and the smoke must spread out in a horizontal sheet.

Another consequence of the large temperature contrasts in dry desert air is the production, where there is a favourable distribution of hills in the neighbourhood, of extremely strong winds; for air will flow from a region of cold descending air to a region of hot ascending air. In Seistan the prevailing wind of this type is N.N.W. and is so strong that great sand dunes form, while sand and stones lifted into the air gnaw away the brickwork of ancient towers; see Fig. 1, for which I am indebted to Sir T. R. J. Ward. In 1905, during the passage of a winter depression, Sir Henry MacMahon's three

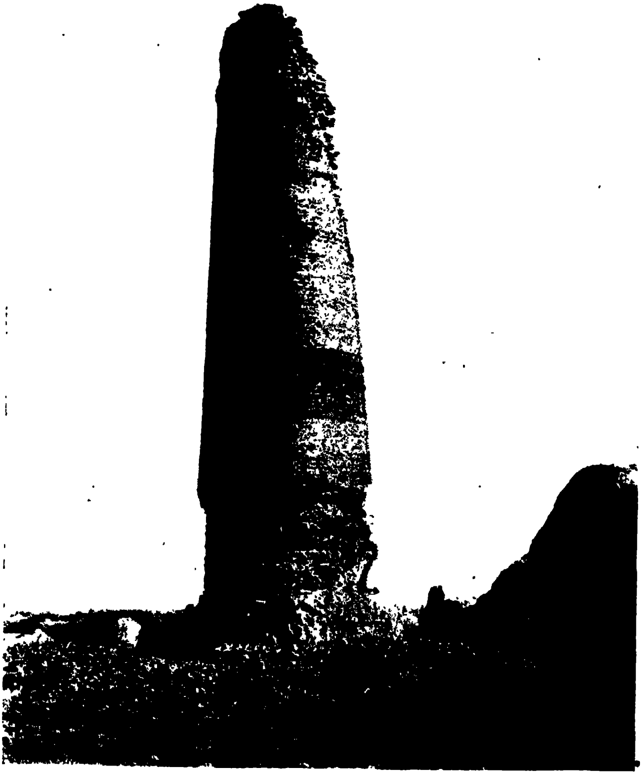


FIG. 1.

anemometers all registered hurricane winds of 90 miles an hour, and an average of 65 miles an hour over 16 hours. An interesting account of his most unpleasant experience will be found in the Journal of the Royal Geographical Society for September, 1906. Similar winds, though of less fury, are, as Sir Aurel Stein tells me, to be met with under analogous conditions in several places in Tibet.

Turning now to India's most characteristic feature, the S.W. monsoon, it is generally accepted that the source of its moisture lies in the winds of the Indian Ocean, shown in diagram, Fig. 2, from Bartholomew's Atlas of Meteorology : the upper currents of air, which arrive by a route over Western Asia, will be comparatively dry. We see that the S.W. winds of the Arabian Sea, which can be traced back across the equator, are in the main, continuous with the S.E. trades, which start near the latitude of Mauritius. The three weeks' journey over the sea affords time for air dry

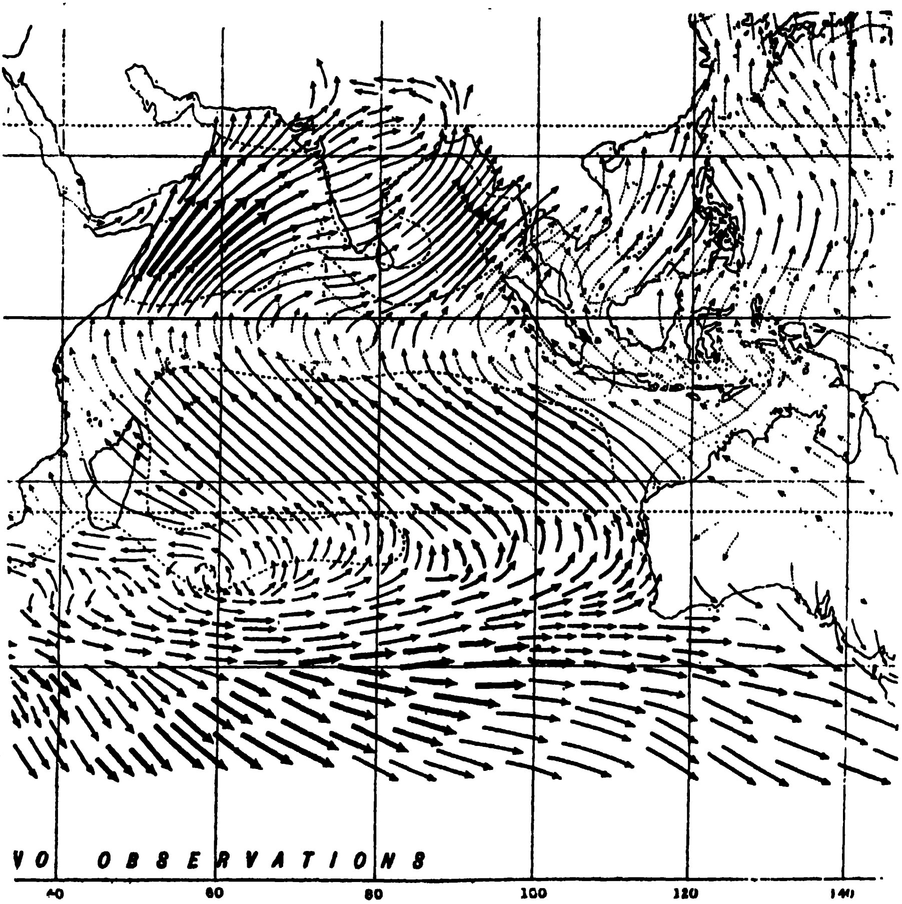


FIG. 2.

at its origin to become saturated with moisture to a considerable height. The need of this is clear, for if all the water vapour in a vertical column of air 20,000 feet high in July under average conditions at Agra were condensed into liquid, it would only produce 2.8 inches of rain ; so the falls of 30 to 40 inches in a day, which occur in the western ghats and the corresponding hills near the Burma coast, combined with moderately heavy rain inland, require a considerable current of moisture-laden air.

I must not linger on the theoretical side of my subject, and will pass on to practical applications. The terrible drought of 1876-1877 led to an insistent demand for some means of foreseeing a failure in the rains, and Blanford, who organised the India weather department, began about 40 years ago to produce forecasts based mainly on the winter snowfall. As the photograph indicates, the N.W. Himalayas are fairly bare in November; but in May they are well covered in some years, while in others the snow-clad area forms but a comparatively small fraction of the total surface. Blanford's successor, Eliot, made a notable advance when he recognised that for a satisfactory prediction it was necessary to examine conditions over the Indian Ocean; but he was almost single-handed, and the difficulties under which he carried on his executive work left him little chance of research over a wider field. It is now clear that the marked difference between the air motions producing abundant and scanty rainfall is associated with marked differences in the conditions over a large part of the earth's surface, some of which precede and some follow the Indian monsoon period; the former may obviously be utilised in

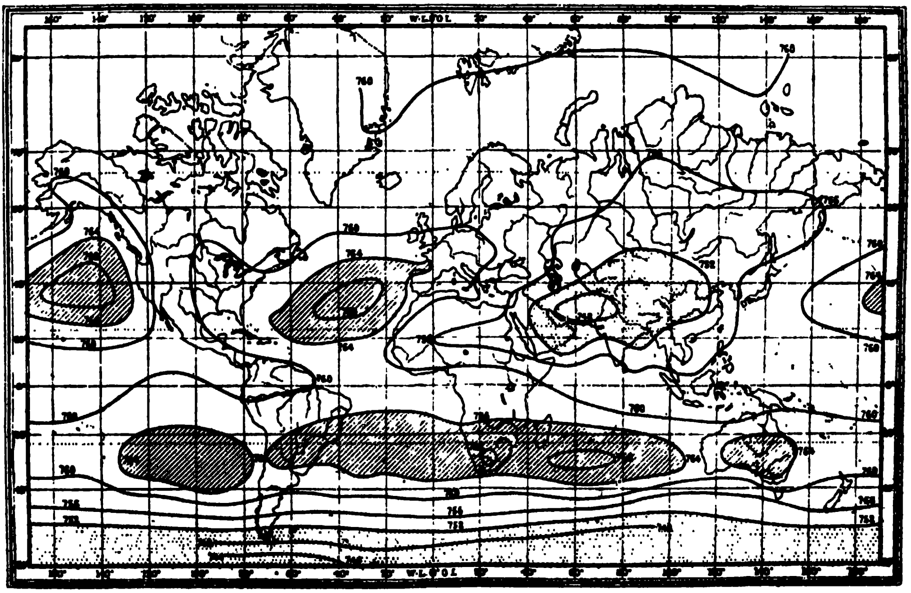
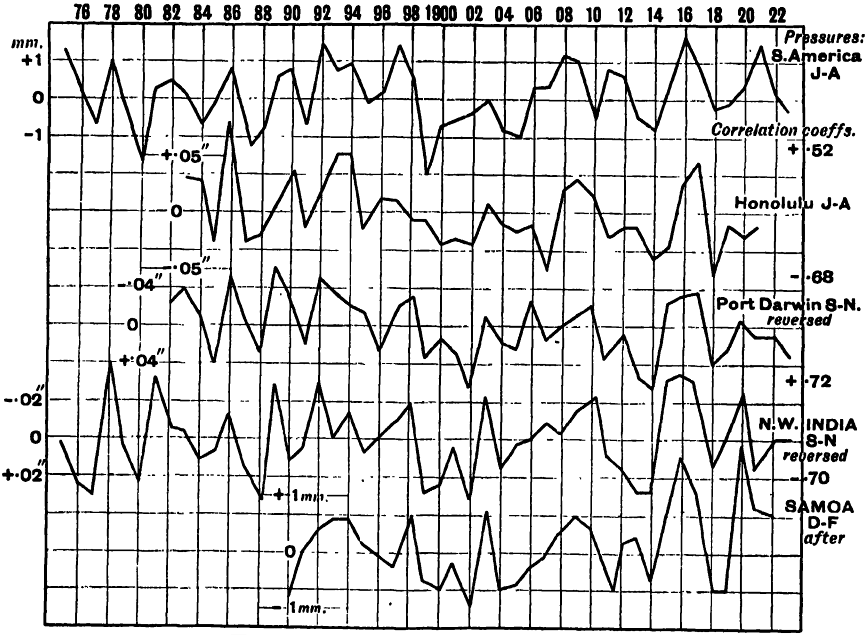


FIG. 3.

forecasting. A glance at the pressure chart of the world in July will show how variations in strength or position of the areas of high and low pressure will determine the rain-bearing winds and so the weather over much of the earth; see Fig. 3, from Hann's Météorologie; such critical places are called " centres of action," and a laborious statistical examination of the relations of each of these with the rest all the year round has brought to light many important facts. Thus we find that abundant Indian rains tend to be associated with low pressure in India, Java, Australia and S. Africa; with high pressure in the central Pacific Ocean (Samoa and Honolulu) and South America (Chile and the Argentine); with previous scanty rainfall in Java, Zanzibar, Seychelles and South Rhodesia; and with low temperature in the Aleutian Islands. The relations between some of these pressure factors are illustrated on the screen; see Fig. 4.



THE SOUTHERN OSCILLATION

Fig. 4.

In 1908, when but a limited amount of material had been examined, a formula for the total rainfall of India was published, of which the performance is given in the diagram. The amount of the excess or defect of the rainfall, as compared with the normal, is plotted for each year, and a line drawn through the points obtained. The calculated rainfall, as given by the formula, is shown by the upper curve and the actual by the lower, and before 1908 the similarity of the two curves indicates the extent to which the formula explained past rainfall. In subsequent years, however, the comparison shows the value of the formula

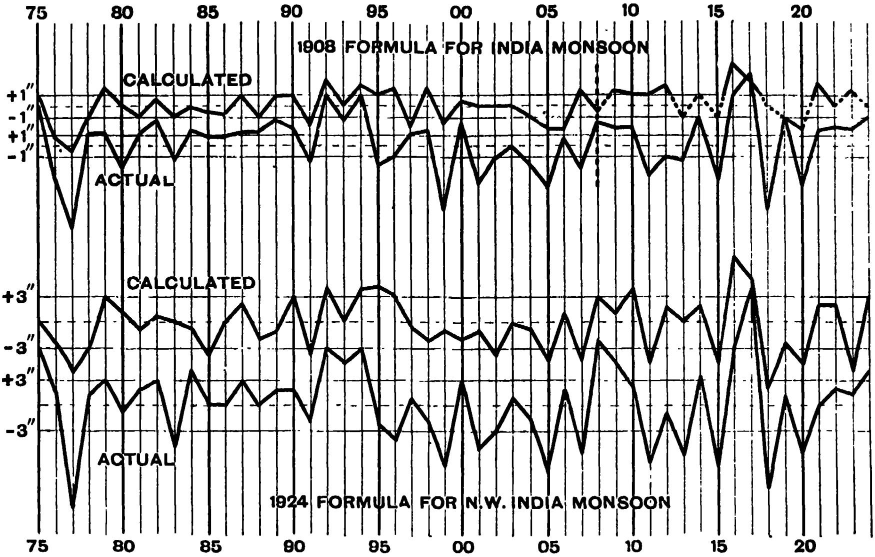


Fig. 5.

as used for prediction. As will be seen, it is only when the indications are strongly marked (as shown by a firm line, not a dotted one, in Fig. 5) that conclusions can usefully be drawn; but out of the 16 years which have passed, there are nine years in which a departure of an inch or more was indicated, and in eight years out of nine the rains were in excess or defect when this was given by the formula. This success is somewhat greater than theory would lead us to expect under the special conditions, but the experience affords ground for hoping that the much improved methods based on more recent work and applied to forecasting the total rainfall of N.W. India or the Peninsula will give results not inferior in usefulness. As an example of recent formulæ we may take that of 1924 for predicting the monsoon in N.W. India. Its ability to account for past abnormalities is shown on the same diagram. It is distinctly better than that of the 1908 formula, but there is only one forecast based on it, that of 1924.

One of the first tasks allotted to the department in 1875 was that of warning for storms at sea, and few who have not experienced hurricane winds can have any idea of their violence. I owe to Dr. Simpson, of the London Meteorological Office, the opportunity of showing you a photograph (Fig. 6) made on a ship in a gale in the South Indian Ocean, and another in the China seas in a typhoon, which is similar to a cyclone in the Bay of Bengal or the Arabian Sea.

One reason why we find it hard to realise the terrible nature of the hurricanes is that we do not appreciate the weight of air, which, though only an eight-hundredth of that of water, is still of serious importance when velocities are

FIG. 6.

high. Thus a man standing in a gale of 50 miles an hour will, during an hour, receive the impact of the air in a column 50 miles long, six feet high and about one foot in width: the weight of this is about 58 tons: thus in every minute he has a ton of air hurled at him.

The havoc wrought by storm winds inland recalls at times the effect of a bombardment or an earthquake. I will put on the screen photographs of the school at Vizagapatam before and after a cyclone in 1923, which breached the railway in many places and caused very general destruction of thatched houses: such damage could not be prevented by warnings from Simla, though these proved of great help to shipping and prevented many casualties. The effects of this storm were, however, almost trivial by comparison with those of some which have crossed the head of the Bay of Bengal. Thus the Bakarganj cyclone of 1876 produced in about half-an-hour a storm wave of from 10 to 30 or 40 feet, and drove this with irresistible fury over the low-lying districts near the mouth of the Megna. In about six hours the loss of life by drowning was 100,000, and the subsequent loss from disease, chiefly cholera, was another 100,000.

In order to provide for such contingencies the system of warning telegrams to port officers and broadcast wireless messages to shipping has been supplemented by an organisation for sending telegrams to local officers in the inland districts of Bengal when they are threatened by a cyclone.

The severest storms usually form either before or after the period of the S.W. monsoon: storms during that period are relatively mild at sea, but cover great distances inland and produce heavy rain near their tracks. On account of the general steadiness of their motion it is not in general extremely difficult to give warnings shortly in advance to those in charge of canals or railways that would be damaged by heavy rain; but there is still much research work to be done. We have photographs of a partial breach in an embankment at Delhi, followed by that of a breach of the Cauvery River. As an example of what can be done merely by excessive monsoon rain without a cyclone, we have a scene in the Malabar floods of last July.

From the appalling destruction wrought by the tornadoes of the United States, India is, fortunately, comparatively free. But in most years examples occur of trains being blown from the lines by winds associated with thunderstorms of exceptional violence, though the funnel-shaped cloud that is characteristic of a tornado is not always reported. I know of no reproductions of the amazing way in which the destruction of an American tornado ceases at a sharply defined boundary, a grand piano being carried away from one side of a room while in the other the photographs on the mantelshelf are untouched; but in 1900, at Goalpara, a tornado wiped out five or six villages and carried a few men over a hundred yards, while in 1899 at Moradabad 230 persons were

FIG. 7.

killed, those out in the open being pounded to death by hailstones. The photograph before you (Fig. 7) shows the effect of a tornado last year at Bareilly which led to a serious railway accident, with the loss of about 30 lives.

The value of a knowledge of upper air conditions to aeronauts needs no emphasis after the triumphal return of the R33, in which the information given by the English weather service played an important part; and although a beginning of the organisation of kite and balloon ascents was made under Mr. Field's charge in 1904 and a considerable amount of work had been done by a temporary staff in observing facts and making them available for aeronauts and meteorologists, it was not until last year that our struggles to have this work put on a permanent footing proved successful. At Agra we have now a well-equipped central observatory, and there are about eight subordinate stations sending up daily small pilot balloons two to four feet in diameter, usually reaching in clear weather to heights of about 20,000 feet. A pilot balloon drifts with the air as it rises through it, and so its path shows the direction and strength of the horizontal currents when watched through a theodolite. From time to time at Agra we also send up rather larger sounding balloons, carrying instruments weighing an ounce, and bringing down a record of pressure and temperature during their ascent.

We have on the screen an uneducated peasant who has been taught to make balloons of thin gutta-percha sheet, and two coolies bringing back an

FIG. 8.

instrument that they have found, in order to secure the reward that is promised on a label. It is expected that the assistance rendered by us to aeronauts in warnings of storms or strong head winds will be reciprocated, and that their observations will throw light on the processes taking place in the air. The photograph, due to Captain Douglas, shows how insight into cloud formation has already been obtained by flying through layers of cloud, the wave-like motion being here conspicuous; and in a second photograph (Fig. 8) we see how different a cloudscape seen from above is from one viewed from the ground. It is, unluckily, hard to make photographs of sunsets in their natural colours; but I have been able to secure one example from the useful collection of the Royal Meteorological Society.

I have tried to indicate some of the ways in which meteorology alone is vitally connected with the economic life of a nation; I will now draw your attention to some developments in co-operation with other sciences.

The relations of meteorology and medicine are of rapidly growing importance. The Weather Department issues warnings to the medical of the danger of sun-troke or heat apoplexy when the wet bulb temperature approaches 85° F.; and both humidity and temperature have a big influence on the incidence of disease. We have on the screen a diagram illustrating the close control of the rainfall of July and August on the malaria of the succeeding October and November in the Punjab: and you will notice how suddenly the relationship ceases after 1910: this unfortunate spoiling of our diagram is, I believe, due to the activity of the Medical Department in the administration of quinine. Nowadays the rainfall data are annually used to forecast in what parts of the Punjab malaria will be serious; and local arrangements are made for combating the disease before its activity has developed.

In connexion with forestry a matter of the greatest importance was that of the influence of forests on rainfall, and the Government of India accepted the opinion of the department that while the direct effect on rainfall of the destruction of forests was inappreciable, the indirect effect on the humidity of the soil was enormous. As we see on the screen, the disappearance of the roots of the trees leads to the washing away of the soil which they assisted to hold in position, and after a day's heavy rain the water runs away rapidly instead of soaking into the earth and trickling into the streams for weeks or month safter. Channels get scoured deeper and deeper and ultimately the level of the subsoil water falls so low that the growth of crops becomes very difficult.

A scheme that I was trying to promote recently was that of cooling the air in big Government buildings, such as secretariats. Over the large part of India in which the air is dry during the hot weather, the process of cooling it by 15° would not be expensive if the necessary appliances were inserted when the building was erected. On entering the cooled premises it might be desirable to wear a light overcoat for a few minutes; but after that no difficulty would arise, and the circulation of fresh air at a moderate temperature adds considerably to mental activity. The cost would be but a small fraction of the salaries of the officers employed, except in regions where the air is damp and special arrangements would be necessary for drying it, like those which are generally employed in cotton mills. However, the present time is not financially favourable for these proposals.

Finally, a few remarks on the economic and social relationships of meteorology, which in India are of exceptional importance, because rainfall affects the area of land which is placed under cultivation as well as the success of the crops ; it affects the incidence of malaria and plague, and on these depend the population available for tilling the soil and working in factories. Thus, while it is essential for steady progress to learn by statistical methods what are the relationships between the factors controlling national well-being, it is clear that weather is one of the most important of them. We have before us a diagram which I once prepared to show some of these factors in Bengal; and in order to bring home to you the need of care in handling such matters, I will put before you a diagram of which the two top curves appear to show that in England illiteracy at marriage produces an abundance, not a dearth, of employment. These curves are taken from authoritative sources, and the two lower curves will, I hope, remove the shock that some of you may be feeling. They demonstrate that a revival of trade has two direct consequences. In addition to the obvious diminution of unemployment it makes marriage possible for a number of the manually working classes; thus it also increases the proportion of those who make their marks in the marriage registers instead of signing them. In order, therefore, to derive reliable conclusions I hold that an examination of such questions is worthy of the best brains that India can produce.

Before sitting down I would like to acknowledge the greatness of the debt which the Meteorological Department of India owes to my colleagues for the developments that have been effected during the past 21 years. In particular I would mention Mr. J. H. Field, Dr. G. C. Simpson, now Director of the English service, Dr. C. W. B. Normand, and R. B. Hem Raj, who sacrificed his life in the cause of the allies by concealing a serious illness in order that he might continue his important assistance in an under-staffed office.

DISCUSSION.

THE CHAIRMAN (SIR REGINALD MANT) said there were many points in Sir Gilbert Walker's lecture which he would be tempted to discuss if time permitted. For instance, his explanation of the cold weather line was most interesting to those of them who knew and loved the Punjab hills and had so often seen that remarkable straight line which appeared on the southern horizon on clear October evenings, and marked the end of the rains and the advent of the cold weather. Sir Gilbert had not explained why the boundary between the colder air below and the warmer air above should be so straight, but the speaker supposed it was because the plains were so flat and the air so still. Then there were the relations of meteorology and medicine, and storm warnings to ships and canal engineers, but there were experts present who, he hoped, would speak on these subjects, and as the time was limited he would confine himself to a few general aspects of the subject.

The weather was probably the most common topic of conversation in this country, but if the farmer, the sailor and the aeronaut were excepted, it was not a matter of vital importance to most people. Broadly speaking, it affected their convenience and recreations more than their livelihood. But in India, where the great bulk of the population were dependent on agriculture for their daily bread and most of the crops grown required seasonal rains, the course of the monsoon was really a vital matter. So the forecasts of the monsoon constituted one of the most important, as well as the most difficult, of Sir Gilbert Walker's tasks in India, and it was, the speaker thought, in the investigation of this problem that he had made his greatest contribution to the sum of human knowledge.

When the speaker first visited Sir Gilbert's office in Simla many years ago he was struck with the immense amount of spade work that he was doing. He had rows and rows of pigeon-holes in which he collected all sorts of curious coincidences. When he found two different phenomena varying in unison over a series of years, he put them into one pigeon-hole and eventually into one diagram, although to a layman there might seem to be no possible causal relation between them. He came away with the impression that meteorology was simply a jumble of observed coincidences. The monsoon forecasts themselves gave some colour to this view. He fancied the prophets had always worked on the same lines in different ages. The old Roman augurs were guided by omens, such as the flight of birds, and in much the same way the monsoon forecasts referred to good and bad signs. Low pressure in Java and high pressure in South America were good signs, while heavy rain in the Seychelles was a bad sign, and so on. The good and bad were set against each other, and if on the balance the omens were favourable a prosperous year was predicted.

The speaker once had the hardihood to make a suggestion to Sir Gilbert for his local Simla forecast, in which he used to tell them every morning what weather to expect in the afternoon. His suggestion was that during the monsoon months, when it rained nearly every day, he should have a standing prediction of " some rain." If there was moderate rain the forecast would obviously be right, and if the rain was torrential, as it often was, he could say that he was prophesying in American, " *Some rain.*" Sir Gilbert never acted on that suggestion. Perhaps he thought it was flippant. The speaker learned afterwards to pay more respect to his methods, and he had shown them that day how frequently they brought out correct results. In fact, he thought he had shown them that meteorology in India had made immense strides under his direction during the last twenty years. But he was still not clear how far he had established, or even envisaged, a causal connexion between the various phenomena which he had shown to be correlative. He had told them that abundant Indian rains tended to be associated with certain pressure factors in various parts of the world. He would like to ask him whether these factors were to be regarded as causes, direct or indirect, of the rains, or whether the meteorologist was still in the stage of observing coincidences. For instance, did the high pressure in South America actually produce conditions favourable to Indian rainfall, or was it even an effect or manifestation of some common cause which produced those conditions ? He had no doubt that Sir Gilbert had at least a working hypothesis in this connexion, and he hoped he would let them into the secret of it.

When the causes of the variations in the periodic rainfall in India had been scientifically established, the fascinating question would arise whether man could do anything to control them. He noticed in Sir Gilbert Walker's paper only one instance in which it had been possible to modify the processes of nature, and that was a very small one, the canvas screen round the skating rink at Simla. Sir Gilbert rejected the theory that the destruction of some of the forests of India had any appreciable effect on the rainfall. The speaker had himself had occasion to study the papers on this subject and had no doubt that the conclusion of the Meteorological Department was correct. But there was another great physical change which had been effected in India in recent years, and which might conceivably have climatic effects—he referred to the conversion of many millions of acres of desert into cornfields by canal irrigation. He had heard it stated that in the Punjab, where the largest area had been redeemed, the climate had been improved, if not by more regular rainfall, at least by mitigation of the intense heat of the summer. Perhaps Sir Gilbert could tell them whether his statistics showed any evidence of material changes, and whether he thought there was any possibility of canal irrigation affecting the winter rains in Upper India, which were so important for the wheat crop.

He could not think of any other direction in which human operations were likely to influence the broad movements of the weather in India, but, as he said in his opening remarks, Sir Gilbert Walker had devoted himself assiduously to the service of this wayward mistress, and he would like to know from him whether he thought that man could ever hope to be her master.

Sir Edward A. Gait, K.C.S.I., C.I.E., said that Sir Gilbert Walker had omitted to tell them that the Indian Meteorological Department, over which he presided so ably for nearly twenty years, bulked much more largely in that country in the public eye than did the corresponding department at home. There were two reasons for this. The first was that India was primarily an agricultural country, so that variations in the rainfall in India had a much greater effect on the crops than in England. The second reason was that the Indian Meteorological Department was more ambitious than the English one, for whereas the latter confined its public prognostications to a period of 24 hours, the Indian Department endeavoured in the spring to foretell the course of the whole of the monsoon rains lasting for a period of three or four months. The author had traced the gradual development of meteorological science in India and had shown how at the beginning the forecasts of the course of the monsoon had been based entirely on the state of the snows in the Himalayas. That was only one of many factors determining the result, and he knew from his personal experience that the information originally collected was not very accurate. The idea at first was to get it from the District Officer. Close on forty years ago, shortly after he had been posted to a sub-Himalayan sub-division, he received a letter asking him how much snow had fallen in the hills. The Tibetans who came down in the winter months had returned to the hills, and he had no means of getting accurate information. But he was too young to admit defeat, and so he made what enquiries he could from the local people, who were almost as ignorant as himself, and sent in his report to the Deputy Commissioner. The Deputy Commissioner adopted his report as his own; the local Government did likewise, and the forecast regarding the probable course of the monsoon in Assam was thus upon the report he had sent in! Matters had moved a great deal since those days. Sir John Elliot discovered that the conditions in the Indian Ocean were an important factor.

Then it was found that the rainfall in India tended to vary inversely with the height of the Nile, then that the conditions in South America had an important influence, and now data were collected from all over the world and were used to forecast the weather in India. The stage had now been reached at which there was a reasonable degree of accuracy in the forecasts. He would like to ask one question of the author—namely, whether there was any explanation of the way in which a small area was sometimes neglected by the monsoon, although the areas all around it had copious rains. Was this a matter of mere chance, or was there some scientific explanation ?

Dr. G. C. Simpson, C.B.E., F.R.S. (Director of the Meteorological Office) supposed that no Government established a meteorological service without the definite aim of providing something which the people needed. In other words, every meteorological service had definitely a practical aim. If that was so he would like to ask some of the administrators present whether they did not think that the meteorological service in India had well fulfilled the purpose for which it was founded. The Meteorological Office there conducted work connected with the warning of ships, warning of floods, and warning even of the danger of sunstroke. From his own experience in India he was quite certain that the whole cost of the Meteorological Office had been frequently repaid in some small work which had hardly been recognised by the public. There was one branch of the work done in India which few people realised—namely, the constant, daily, steady accumulation of data, as a result of which the meteorological conditions were probably better known in India than in most other civilised countries, and certainly better than in any tropical part of the world. India, therefore, needed no justification for its meteorological department. But India had been served by three directors of its meteorological department—Blanford, Eliot and Walker—who, before they were meteorologists, were scientists, and they had realised that one could not undertake any application of science before the science itself was understood. The only way to advance in a scientific subject was to do the science first for its own sake, for the knowledge it afforded, without any ulterior motive. That was realised by Sir Gilbert Walker as much as by any one. When he (the speaker) went to India in 1906 Sir Gilbert allowed him to work at atmospheric electricity, which, as far as was known, had no direct bearing upon anything done by the department. He allowed another worker to investigate the upper air, and in those days no one could say why such investigation was necessary. But what had happened ? The investigation of the upper air was being applied to a new kind of navigation, which was never considered at the time. So one felt that all along the line this sort of work was justified. There were any number of questions which might be asked on the paper. The more that administrators asked those questions the more confident would those in charge of meteorological departments feel in asking them for money to aid their investigations. Speaking with a considerable amount of knowledge of meteorological services in various parts of the world, he could say that the meteorological service in India compared favourably with every one of them, and he hoped that its future would always be equal to its past.

Lieut.-Colonel Sir Leonard Rogers, C.I.E., F.R.S., M.D., showed a number of maps and diagrams to illustrate some recent work on the distribution of certain diseases in India in relation to the rainfall, the humidity, and the prevailing winds. He mentioned that it was now just over thirty years ago since he began to work on the relation of malaria to climatic conditions in India. This varied greatly. In some places there was a close relationship between the amount of rain and the malaria, but in Eastern Bengal the condition was exactly the opposite to what it was in most parts of India, and there was least malaria when there was most rain. If the monsoon went on late there was only a short drying up period before the minimum temperature fell to 60 deg., and as soon as the minimum temperature fell to 60 deg., the malaria came down with a run. In Calcutta and its neighbourhood he could not find any relationship with total rainfall at all, and it was not till he had worked it out day by day that he found that there was most malaria when there were breaks in the monsoon, which allowed the mosquitoes carrying the malaria to breed in enormous numbers on the country-side. He had formally drawn the attention of the Government of India to the question, but not till some years afterwards did he hear that it was considering the issue of forecasts. Colonel Gill had issued forecasts for about three or four years, stating what areas were going to get most malaria, and they had "come off" absolutely. There were wonderful meteorological records available in India. He showed a map illustrating the distribution of leprosy in India in relation to the rainfall and to the geological character of the land also. Everywhere with a high rainfall high leprosy rates were met with. In the case of tuberculosis there was an extraordinary low rate in the very rainy district of Assam, which was difficult to account for at first sight, but when the data with regard to humidity and the rain-bearing winds were considered an explanation was seen. His map showed diagrammatically how moist currents might extend much further than the area of actual rainfall, which accounted for the high tuberculosis rate in certain areas which did not have a great rainfall; these areas were under the influence, nevertheless, of these moist winds. But in Assam, with its high rainfall and its low tuberculosis rate, there was a protection by certain elevations against the monsoon wind. Although there was heavy rain in this region, there was not the direct monsoon current. These data agreed exactly with what had been found in Devonshire, where the high tuberculosis rate was found in places exposed to the rain-bearing moist winds. There was a portion of country in southern central Madras which showed apparently a high tuberculosis rate and a low leprosy rate. The explanation was that there were gaps in the hills which exposed the country to the influence of the wet winds. The incidence of pneumonia accounted for a clear-cut picture on the map of India. A high pneumonia rate was found up in the North-West Frontier; 60 per cent. of the pneumonia cases occurred in the cold weather months. The minimum temperatures were shown to be down to 30 or 35 deg. in the area of the high pneumonia rate. His map showed in the areas where there was a high pneumonia rate a diurnal variation of temperature of over 30 deg. The high pneumonia rate was in relation to the cold and dry atmosphere and the great diurnal variations of temperature. Although it was well known that pneumonia was due to the pneumo-coccus, that organism was present in the throats of an enormous number of people who never got pneumonia, and it was necessary to seek a further cause, and that was chill. There was another condition which he was not able to illustrate by means of a map, but which had been the subject of some recent investigation on his part. This was smallpox. In this country not very much smallpox had been seen of recent years, although the fact that one-third of our children were not vaccinated laid us open to the possibility of a serious epidemic, and in America a very fatal outbreak had been experienced. He had worked out the monthly figures for India from 1877 up to the present day. The figures showed that smallpox always came down in the rainy season, and he had discovered that whenever there was a year of very deficient rainfall the following year saw an outbreak of smallpox. In the case of eight different outbreaks in Bombay, each outbreak had followed a year of low rainfall. His explanation was that there was always a great fall in smallpox during the rainy season, when the humidity was at its height, and that in years of exceptionally low rainfall the humidity did not rise high enough to bring about the usual decrease, so that there was already a legacy of cases, as it were, before the ordinary seasonal increase with the onset of cold weather began, and this led to an epidemic. It should be possible, therefore, to forecast an outbreak of smallpox in the future. He spoke of the enormous value of such data as had been accumulated by the Meteorological Department.

SIR THOMAS R. J. WARD, C.I.E., M.V.O., M.Inst.C.E., thanked Sir Gilbert Walker and his able adjutant, Dr. Simpson, for the invaluable work they had done, more especially in assisting irrigation in India. The working of canals was a very complicated problem, into which there was not time to enter at that moment. The downfalls of rain, although very regular on the average, in detail varied considerably, coming sometimes early and sometimes late, and the farmer had often to consider whether he would take canal water or would wait for the rain. If he took canal water and the rain came, he ran the risk of being over-irrigated. Dr. Simpson had urged on him at a time when he (the speaker) was in charge of one of the irrigation works in the Punjab that if he proved right in his forecasts twice out of three times, he should place himself in his hands and regulate accordingly. At that time he (Sir T. Ward) did not give him a very encouraging answer, but now, being out of the " fray," he was glad to recognise his courage, and to admit that Dr. Simpson's method, that of trial and error, was the only one whereby meteorology could be made of help to the farmer. He found that the younger generation of irrigation officers studied the weather forecasts very carefully, and regulated their doings very largely by those forecasts. It was too late in the evening to enter into more detail, but he would like to say that the farmer of India was one of the most progressive in the world. He pointed to the wonderful steamships and railways, docks and canals, which connected up the Indian farmer with the markets of the world. It might be said that these were started as Imperial communications. He was inclined to think that the people who pioneered them suggested the Imperial communication as a camouflage in order to provide the farmers with the necessary facilities, knowing well that when once they were provided the farmer would fully utilise them. Even in the time he had been connected with India, these steamship lines and docks, railways and canals, had been extended and rebuilt many times, and always the cry was for better facilities and more of them. He felt sure that if Sir Gilbert Walker's successors would only rely on the farmer's readiness to avail himself of facilities that would produce good results, meteorology in India would have an even greater future before it. He knew that his own successors in India gratefully appreciated the work of the great scientists of the Meteorological Department, and he would like to record the enormous help they had been to himself.

MR. R. à-ABABRELTON asked whether the concussion of air which took place during the war owing to explosives had any influence upon weather conditions. He found that this was believed to be the case in South Africa, owing to the great changes in those conditions which were noticed after the War of 1899-1902 for some years, especially in Natal.

SIR GILBERT WALKER, in reply, said that with regard to the evenness of the cold weather line to which the Chairman had alluded, he fancied this was mainly due to the stillness of the air and the fact that the cold air down below was the heavier. He had been asked whether monsoon forecasting was on a scientific basis or was merely empirical. It was frankly empirical, but the only way in which so complicated a matter could be handled was by finding out the facts empirically first. The general idea in their minds when forecasting was that the variations conditioning a good monsoon were those associated with the strengthening up of the general circulation of the air, and *vice versa*. The question whether there was any influence traceable on the climate of the Punjab from the extension of canal irrigation carried, he thought, a negative reply. The clearest instance in which it might be hoped to find an effect of irrigation was right in the heart of the canal-irrigated region, but if one drew a diagram of the changes in humidity from year to year and endeavoured to find out some place in which there was a discontinuity it was quite impossible to see it. Being unable to find any change in humidity due to this cause, it seemed to him unlikely that there was any change in other respects. With regard to the possibility of man becoming master of the weather, he thought that Sir Napier Shaw had come to a negative conclusion.

The effect of war and explosions on Indian rainfall excited a good deal of interest so far as the newspapers were concerned. For several years every time there was a special outburst of rain it was regarded as being due to gunfire in Europe, and equally when there was an absence of rain it was put down to the same cause. In point of fact he did not think there was the slightest chance of this having had any influence. The amount of force exerted was entirely out of proportion to the amount of force that would be required to produce any effect. An experiment had been tried to protect crops, especially vineyards, against hail. For scores of years there had been a belief in Italy and Austria, and at times in America, that if a gun were fired into the air so as to produce a large explosion it would bring down the humidity of the clouds as rain and not as hail. The conclusion they came to in India was that it had no effect whatever.

SIR ALFRED CHATTERTON, C.I.E., proposed a vote of thanks to Sir Gilbert Walker for his paper and to Sir Reginald Mant for presiding. He said that every one would agree with him that it had been a pleasant and instructive afternoon. He had had very little to do with meteorological problems himself, except in connexion with the development of power from the winds. He applied to the Meteorological Department for information and came to the conclusion that a certain place in the Deccan was the windiest place in India and most suitable for windmills. Afterwards he found a very large number of windmills set up in that region. Another matter which had interested him was that on one occasion in Madras he saw one of those tornadoes of which the lecturer had spoken, the amount of destruction in a comparatively short course being extraordinary. It had often occurred to him that if it was known exactly how these tornadoes were formed it would be a very good thing to manufacture artificial tornadoes, in addition to our other air defences, and direct them in the course of hostile aeroplanes or airships.

The motion was carried unanimously.

GENERAL NOTE.

FOREST PRODUCTS RESEARCH.—The Lord President of the Council has appointed Mr. R. S. Pearson, C.I.E., F.L.S., (Forest Economist, Forest Research Institute, Dehra Dun, India) to be Director of Forest Products Research under the Department of Scientific and Industrial Research. Mr. Pearson will be in charge of the Forest Products Research Laboratories, in which pure and applied scientific research will be carried on to meet the practical needs of the using industries and of Departments of State. In 1917 Mr. Pearson contributed to the Society a paper on "The Recent Industrial and Economic Development of Indian Forest Products."

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

EXHIBITION OF INDUSTRIAL DESIGNS.

VISIT OF H.M. THE QUEEN.

On Thursday, July 30th, the Queen, attended by Lady Bertha Dawkins, honoured the Royal Society of Arts by visiting the Exhibition of selected works submitted at the Society's Annual Competition of Industrial Designs, which is now being held, by the courtesy of the Director, in the North Court of the Victoria and Albert Museum, and will remain open until August 31st. Her Majesty was received by Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., Chairman of the Council, Sir Charles Allom, Chairman of the Architectural Decoration Section, Mr. J. A. Milne, C.B.E., Chairman of the Book Production Section, Mr. Eric Maclagan, C.B.E., Director of the Museum, and Mr. G. K. Menzies, Secretary of the Society. The Queen evinced great interest in the Exhibition, and carefully examined all the work exhibited.

DOMINIONS AND COLONIES SECTION.

MONDAY, JULY 27TH, SIR RICHARD REDMAYNE, K.C.B., M.Sc., M.Inst.C.E., M.I.M.E., M.I.M.M., F.G.S., in the Chair.

A paper on "The Mineral Resources of Northern Ontario" was read by PROFESSOR W. A. PARKS, Ph.D., President, Royal Society of Canada; President, Geological Section, British Association, 1925.

The paper and discussion will be published in a subsequent number of the *Journal.*

INDIAN SECTION.

A meeting of the Indian Section Committee was held on Friday, July 31st. Present: Sir Edward A. Gait, K.C.S.I., C.I.E. (Chairman of the Committee) in the Chair; Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S. (Chairman of the Council); Sir Charles H. Armstrong; Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I.; Sir M. M. Bhownaggree, K.C.I.E.; and Major H. Blake Taylor, C.B.E., with Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, JUNE 12TH, 1925.

SIR LOUIS W. DANE, G.C.I.E., C.S.I., in the Chair.

THE SECRETARY of the Section announced that Lord Lamington, who had promised to preside, was, unfortunately, unable to be present owing to indisposition and that his place had been taken, at short notice, by Sir Louis Dane.

THE CHAIRMAN, in asking Sir Percy Sykes to read his paper, said that his knowledge of Persia was so intimate that he had frequently been described as Sir "Persia" Sykes. It was hoped that his most talented and energetic sister, Miss Ella Sykes, would add something at the end of the lecture. Sir Percy had already rendered yeoman service to the Royal Society of Arts. In 1897 he read a paper there on "Kerman and Persian Baluchistan, with special reference to the journeys of Alexander the Great and Marco Polo"; one in 1906, with the late Lord Curzon of Kedleston in the chair, on "The Parsis of Persia," and a third in 1914 on "Khorasan, the Eastern Province of Persia." He had also taken part in discussions at meetings of the Society. The remarkable lantern slides which would be shown by Sir Percy that afternoon were made for the series of Lowell Lectures delivered by him last year at Boston, U.S.A., and had never before been exhibited in this country.

The paper read was:—

THE HEART OF ASIA AND THE ROOF OF THE WORLD,

By BRIGADIER-GENERAL SIR PERCY SYKES, K.C.I.E., C.B., C.M.G.,
Gold Medallist of the Royal Geographical Society.

During the course of my travels in Central Asia I had visited Bokhara the Noble, and I had stood by the tomb of Tamerlane at Samarcand. But I was not content, and wished to go farther East and visit the mysterious cities of Yarkand and Khotan, in the very heart of Asia, while I was equally anxious to climb to those remote uplands, the Pamirs.

In the spring of 1915 I was suddenly ordered to take up the appointment of Consul-General for Chinese Turkestan, and immediately began my preparations for yet another journey Eastward Ho! My sister, Miss Ella Sykes, who had travelled widely in Persia with me, offered to accompany me on what she knew would be an arduous expedition, and, as my narrative shows, materially contributed to its success.

Our outward journey was slow owing to the strain of the war, and it took us nearly a month to cross Scandinavia and the Russian Empire to Osh. There we engaged a caravan of ponies, and after a difficult passage of the lofty Tian Shan range, we reached the borders of Chinese Turkestan.

The country is a vast plain, measuring about 1,000 miles from east to west, and perhaps half that distance from north to south. It is surrounded by some of the loftiest mountains in the world, the Tian Shan to the north, the elevated land mass of the Pamirs to the west, and the Kara-Koram and Kun-Lun to the south. The eastern boundary is the vast Gobi, or "Desert," which is nearly one thousand miles wide. The waste of the Takla Makan, as distinct from the Gobi, occupies the heart of the country. Indeed, Chinese Turkestan may be best described as a desert, fringed by oases, forming a horse-shoe with the toe pointing west. The oases constitute about 1½ per cent. of the area, so that if the deserts, which are entirely unproductive, were excluded the country to be dealt with would be very small.

The oases, separated from one another and the outside world, produce practically all essentials, with the result that there is a general state of well-being, which tends to contentment and removes any desire for progress. The crops depend entirely on the water that flows down from the surrounding ranges, as the rainfall does not count. Just as in Egypt, a full river means prosperity whereas a low river means scarcity. Unfortunately, the snowfall in the ranges is decreasing. The population of Chinese Turkestan is about one million and a half, confined almost entirely to the oases, the sole exception being the nomads who graze their sheep on the slopes of the ranges.

We were welcomed on the frontier by a representative of the *Taoyin*, or Governor-General, a striking personality, wearing a scarlet and yellow plastron with words denoting his official position of *Ya-yieh*, or "Yamen Runner," a name which recalled to me the old English Bow Street Runners. We marched in the mountains for several days, but the country gradually became more open, and at last we camped on the edge of a great plain, and saw the oasis of Kashgar in the distance. In accordance with the courteous Chinese custom, we were met and entertained with refreshments first of all by Sir George Macartney, whom I replaced, and by the British-Indian traders, then by the Russian Consul-General, and finally by the Chinese officials. After taking over charge of the Consulate-General, one of my first duties was to pay an official call on the *Taoyin*. In the East official calls demand formalities that are happily absent in the West. The Chinese Secretary busied himself in preparing my visiting card, and after much cogitation, he evolved *Si-ki-su.* He was much pleased with the result of his arduous labours, for although four or five syllables are considered to be pretentious, two are held to be insignificant, whereas, through his skill, he had evolved the golden mean with three. These three syllables were printed on red paper, and the first stage of the preparations for the call was thereby completed. I felt that undue importance had been assigned to the matter, but happening to inquire how long the Chinese had used visiting cards, I was informed that it was an established usage for many centuries before Christ. This reminded me that I was dealing with a people whose civilisation was not only very ancient, but who had had no break with the past—for example, the descendants of Confucius, a contemporary of Cyrus the Great, are well-known in China to-day. On the appointed day I drove to the Yamen, which is guarded by grotesque plaster lions, which are believed to keep off evil spirits, and by a few shabby Chinese soldiers. Weird music was played from a high latticed gallery, and crackers were let off to signify an artillery salute. The horses finally pulled up at the great wooden doors, which opened as I alighted. The etiquette was to leave the carriage and proceed across a stage with an altar on one side, Jafar Bai, the head servant who had gone round, preceded me, holding up the red visiting card and calling out my rank with, I imagine, a good deal of exaggeration. As I stepped into the inner court, the *Taoyin* also entered it from his audience chamber, and we met exactly in the middle and exchanged many compliments before sitting down and partaking of tea.

My sister and I are both inveterate sightseers, and the bazaars delighted us, especially on market days, when crowds of people poured in from every hamlet and farm in the oasis, making a feast of colour. The *Begs*, or landowners, were usually fine men with handsome features, full beards and dignified bearing. They invariably rode, regarding pedestrians with contempt. In complete contrast were the hairless, flat faced, ruddy Kirghiz, with their almond-shaped eyes and high cheek-bones, while the peasantry were Aryans, with a strong touch of the Mongol. Both sexes were gaily dressed. The men wore long striped robes of many colours, that recalled Joseph's coat. Snowy turbans denoted *mullas* or merchants, but the others in velvet hats, embroidered with fur, made an equally pleasing picture. The women "resembled a flower garden," as a Persian poet would have said. They used the brightest colours with complete success, so strong was the sun—and so good was their taste. In Persia women are closely veiled, and nominally so they are in the Kashgar oasis, but as a matter of fact, outside the town they usually kept their veils up, partly owing to Chinese influence. Both men and women wear abnormally long sleeves, to serve as gloves in the cold weather, and, when travelling, long leather boots are donned by both sexes, so much so that we dubbed the country the "Land of the Long Boot."

The bazaars displayed various sorts of wares, and there was much chaffering in proportion to the business effected. The dyers hung their cloth to dry in any convenient corner, the shoeing-smiths lashed the very quiet ponies to a frame before attempting to shoe them, and the bakers, whose ovens were flush with their shops, threw flat lumps of dough against their sides, and pulled them off when converted into "flap-jacks," with the aid of long iron tongs.

One day we visited the chief school, and I was much struck by the similarity of the education with that given in Persia. Indeed, wherever Islam is the religion, the chief, if not the only real subject of study is the Koran. Unfortunately, the methods of instruction are most defective, the pupils merely learning by heart chapter after chapter in Arabic, with the equivalent in Turki, the language of the country.

We rode almost every day, and, in time, visited everything of interest in the oasis. We frequently forded the Tuman Su, where the grooms watered the horses morning and evening, close to where the water carriers scooped up the drinking water into barrels, by means of gourds specially grown for the purpose.

The chief centre of veneration is the shrine of *Hazrat Apak*, the Priest-King of the country in the seventeenth century, whose influence extended to India, where he had thousands of followers. The road leading to the shrine was the *Via Appia* of Kashgar, and, as we rode along, we passed hundreds of women weeping at the graves of their parents. In reality, they were performing a sort of ancestor worship, which they have adopted from the Chinese.

We were courteously received by the custodian at the tiled gateway and walked up an avenue bordered by poplar trees. The shrine was covered with blue and white tiles bearing verses from the Koran, and was surmounted by a shapely dome. We were invited to enter the tomb-chamber, which was crowded with tombs, that of " His Holiness " being conspicuous owing to its red and white coverlet. There were a number of banners and flags, which gave a Chinese touch, while outside were heaped up some fine heads of the great rams of the Pamirs that had been offered by Kirghiz pilgrims.

On a bluff opposite the Consulate was a humbler shrine, which was frequented by women only, and especially by girls, who put up prayers for rich husbands, without fathers or mothers. To ensure the aid of the *Bibi* they inserted their hands into a hole in the shrine, drew out a morsel of earth and swallowed it. When the Saint listens to the prayer and a suitor appears, there is no formal betrothal, although, in the case of the wealthy, the bride is richly dowered. The marriage ceremony is generally celebrated at the end of a feast. An agent of the bride's family going to the women's quarter and, standing behind a curtain, asks the bride whether she accepts the bridegroom on the terms of the marriage contract. This constitutes the legal ceremony, but, in the eyes of the people, the eating of bread soaked in salt water before witnesses is what really counts. Finally, the bride is carried with great rejoicings to her new home, where flour and cotton are set before her to symbolise a happy journey through life, the ceremony being termed " White Road."

We were naturally anxious to visit any Buddhist ruins that we could hear of, but Moslem fanaticism was strong and almost everything had been destroyed. However, at Kashgar there are still left the shapeless mounds of two *stupas*. The villagers called them *Tim*, but could give us no information about them. They may be assigned approximately to the eighth century of our era.

In the autumn we set off on a tour which included Yarkand and Khotan, cities we were most anxious to visit. We engaged waggons to transport our baggage, while we rode two fine Badakshani horses, in which connexion Marco Polo, whose journeys I traced in more than one section, especially praised that breed.

During this journey I enjoyed the very interesting experience of hunting with golden eagles. In Persia, where I had enjoyed a good deal of hawking, I had heard that these great birds were flown at hares, pheasants and even at gazelles in Central Asia, but I could hardly believe that the accounts I had heard were correct. However, one day, I rode out with six or seven "eaglers," if I may coin a word, all mounted on small ponies with superb eagles on their wrists. We formed a line, riding through low scrub. Suddenly a hare sprang up, and immediately an eagle was loosed, and, in spite of the hare twisting in and out among the bushes, it was struck before it had gone sixty yards, so swift is the king of birds. Pheasants had even less chance, and we only regretted that we did not sight any gazelles, as they would have given us a run. I asked how these birds were captured and trained and was informed that a man hid himself among the rocks near an eyrie, holding a live fox on a rope. The eagle swooped down on its quarry, which was slowly drawn towards the concealed hunter. The bird, intent on tearing the fox, was drawn with it and was caught with a net. It is then shut up in a dark room, its eyelids are sewn up, and its spirit is broken by incessant beating of drums, which prevents any rest. It remains morose for a while, but gradually takes food from its captor, to whom it becomes attached. Indeed, I was much struck by the fact that unlike hawks, eagles are rarely hooded, and seem to be perfectly contented with their lot.

The Yarkand oasis is the richest and largest in Chinese Turkestan. Everywhere loads of melons were being stored for winter use, while a fourth crop of the prolific alfalfa was being cut. Kashgar owed its commercial importance to its trade with Russia, whereas Yarkand trades with the Indian Empire across the Kara Koram Pass. In no part of the world is trade carried on under greater difficulties, for the track is only open for six months in the year, and crosses range after range of the highest mountains in Asia, culminating in the Kara Koram Pass at an altitude of 18,550 feet. This range is aptly termed the "Ridge-pole of the World." Add to these physical difficulties, storms, avalanches and flooded rivers, and an absence of villages for six stages, and we can admire the sturdy traders who export the hemp and silk of Yarkand and Khotan and bring back muslins, spices and brocades. All honour to them. Yarkand is a dirty tumbledown town and its inhabitants are afflicted with goitre to a distressing extent. The malady is long standing, for Marco Polo commented on it. I can only hope that there is truth in the reports that a cure has been discovered for the disease.

On leaving the city we rode through a very rich belt of cultivation to the banks of the Zerafshan or Yarkand River, on which the prosperity of the oasis depends. It has a very wide bed, which is filled in the early summer when the snows melt in the mountains, but at the time of our journey, the river was perhaps 200 yards wide. We found ferry boats awaiting us, in which our ponies were packed without difficulty. The waggons, too, were loaded up and we were soon poled across.

Before we reached Khotan, we had to cross more than one bay of the Takla Makan desert. The whole party was excited by these night marches, and a Hindu trader told them of how he and his servants had seen troops with banners marching silently, and then flocks and herds, which suddenly appeared and as suddenly disappeared. Even our horses were influenced by the unreal aspect of the things they passed and shied at bushes as if they were beasts of prey. For myself, there is always a certain sense of boundless space and freedom in the desert. There is also the feeling expressed with such charm by Flecker:

> Sweet to ride forth at evening from the wells,
> When shadows pass gigantic on the sand,
> And softly through the silence beat the bells
> Along the Golden Road to Samarkand.

On one occasion, when marching by day, we were caught in a storm. Immediately the dust enveloped us and a dense yellow haze obliterated the bright sunlight. We decided to gallop on to the stage, as our waggons had fortunately been sent ahead. Mile after mile passed, the horses taking care not to lose the track, when suddenly we galloped out of the haze into the bright sunlight and cultivated fields of an oasis, and enjoyed the pleasure of looking back on the storm raging in the distance.

In this section of our journey we were treading in the footsteps of Marco Polo, and, when reading his description, I had been surprised that he made no mention of the mighty Kun-Lun range to the south. The explanation is that the Venetian traveller never saw the snow-covered mountains owing to the dust haze, as was also our disappointing experience.

The last stage before Khotan lay across a desert and while riding among sand dunes we reached two wooden posts and were informed that they marked the boundary of the celebrated Pigeon Shrine, where all good Moslems must dismount. We followed the example of our men, and soon reached a graveyard, scarcely distinguished by poles, on which hung fluttering banners. Close by we saw a tiny mosque and low sheds, on which thousands of pigeons were sitting. We had brought a sack of grain which was soon opened and devoured by the birds.

Legend has it that *Imam* Shakir, when attacking the Buddhists of Khotan, was killed in battle or, as the Moslem chronicler put it, achieved martyrdom. Two doves are said to have flown from the heart of the martyr and were the ancestors of the pigeons of to-day. Legends have a habit of repeating themselves, and we learn from the Chinese traveller, Hieuen Tsiang that, in his day, there was a shrine sacred to golden-haired rats on this site. The story ran that an invading barbarian host was encamped on this spot and that the ruler of Khotan was in despair. During the night a huge rat appeared to him in a vision, bidding him be of good cheer, and, on the morrow, the Khotan army gained a complete victory, because the rats had gnawed the bowstrings, the harness and the fastenings of the armour of their enemies. From that day the rodents were held in high honour and a temple was erected, where travellers made offerings, any neglect of this duty entailing swift misfortune. It is interesting to note that in the pages of Herodotus there is an account of a victory gained by the help of rodents.

Khotan is a corruption of Yu-tien or the Kingdom of Jade, a stone that is valued above all others in China, being described as "the quintessence of Heaven and Earth." Until the recent revolution it was worn by the Emperor and grandees, and was also buried in their tombs. At present there is less demand by the Chinese, but Europeans and Americans are now eager purchasers of this beautiful stone. The jade mines in the mountains are worked, but the output has little value owing to its softness. The jade that is appreciated is dug up in the river beds of the two rivers that flow through the oasis. We visited the diggings, which merely consisted of holes excavated to a depth of twelve feet in a disused river-bed. Small boulders are found, those we saw being dull green. Had they been white, flecked with green, they would have been worth £200 each, instead of £5. To our great disappointment there were no craftsmen at Khotan, who could carve the jade into beautiful works of art and we had to be content with some bowls of green, or of green flecked with black.

Silkworms were brought to Khotan in very early days, and silk was exported across Persia to the Roman Empire, where it was sold for its weight in gold. The death penalty was inflicted on any one who attempted to smuggle the eggs out of the country, the Chinese naturally desiring to keep the silk industry as a profitable monopoly. The Emperor Justinian made great efforts to secure some of the precious eggs, and one of the romances of industry is the tiny consignment that was brought in a bamboo cane from Khotan to Constantinople by two Persian monks, who, thereby founded one of the staple industries of the West.

I propose now to make a few remarks on the people and their customs. As may be supposed, the peasants are very superstitious, and rely on the magician. In cases of possession by the devil, the magician is summoned and chants: "Another head has come to the head, another body has come to the body. Your master has come, a jade lamp and blood sherbet are here. You will soon be like ashes, for I have an iron knife to cut you with, and coal bullets to shoot you with." The devil is believed to quit the patient without fail on receiving this peremptory summons.

Outside Kashgar there is a shrine famous for the cure of skin diseases. The patient merely takes some mud, throws it against the walls of the shrine and then walks away without looking back.

During the time I spent in Chinese Turkestan I was always on the look out for any customs that had survived the disappearance of the large Christian colonies noted by Marco Polo and later travellers. One such is that dealers, when they fail to sell a horse, make the sign of the cross on its forehead to avert the evil eye.

To sum up, the people are happy and contented, and when I heard them returning home at night, singing lustily their tuneful songs, I thought of Goldsmith's lines:

"How happy he who crowns in shades like these
A youth of labour with an age of ease;
Who quits the world where strong temptations try,
And, since 'tis hard to combat, learns to fly."

PART II.

Of all the mysterious countries of Central Asia, the most remote and the most difficult of access is that known as the Pamirs, signifying the high-lying mountain valleys situated around the sources of the Oxus, the great river of Central Asia. The word was first mentioned by Marco Polo, but it was really introduced into the English language by Matthew Arnold, who wrote:

"Oxus, forgetting the bright speed he had
In his high mountain cradle in Pamir."

The whole country lies at an extraordinary height, the traveller seldom descending below 12,000 feet, from which fact the Persian name for the region *Bam-i-Dunia*, or "Roof of the World," is remarkably apt.

We left Kashgar early in June. The Pamirs are under snow until the end of May, whereas the rivers come down in flood in June. Our route lay south across the fertile oasis, which looked particularly attractive with its abundant harvest of wheat and barley almost ripe for the sickle, while fallow-land was being prepared for the autumn crops of millet and Indian corn.

Two marches brought us to Tashmalik, where we camped under the last trees we were likely to see for many a long day, and the following morning, we entered the low hills and began a trying march up the Gez River. The heat was intense, and was augmented by the glare from the boulders of the river-bed, but we consoled ourselves, if not our ponies, with the reflection that within a week we should perhaps be shivering with cold, while, at any rate, we were treading in the footsteps of Marco Polo. Fording the river was always exciting, especially as, day by day, its volume increased. The last time we forded the river my sister was conducted by a Kirghiz chief, who took special precautions for her safety. The water is so cold and the current so swift that, as in Tibet, a man who falls and is swept away has little chance of escape. The Kirghiz, who ford these rivers on foot, do so by jumping on both feet down stream.

After marching three or four stages up the Gez Valley, we reached a point where the river rushed through narrow, gloomy gorges and were obliged to take to the mountains. The tracks ran along the edges of precipices, where a single slip would have meant falling hundreds of feet into the swift river. Even more dangerous was a section that was carried on a wooden gallery built out from the cliff. It was in a rotten condition and we were all intensely thankful when the party passed safely over.

It seems probable that the system of the cantilever bridge was invented in the Heart of Asia, for the bridges, weak though they might be, were all constructed on this principle. We generally found them in such a bad state of repair that we had to stuff nosebags into the holes before leading our horses across them.

Within a week we reached the country of the Kirghiz, and at Bulunkul we were welcomed by a leading chief, Osman *Beg*, who had furnished us with the information on which we had depended for the journey. Some *akoi* were placed at our disposal. Their framework is a wooden trellis, set in the ground in a circle eighteen feet in diameter. On this foundation wooden laths are fastened, their upper ends being fitted into a thick wooden hoop. Felts are now bound on to the framework, leaving the centre of the dome open, to allow the smoke from the open hearths to escape. This completes the description of Matthew Arnold : " a dome of laths and o'er it felts were spread." Although we certainly retain keen recollections of the blinding smoke of these *akoi*, they were frequently veritable havens of refuge to us, and we shall always look back to them with feelings of gratitude.

My sister was welcomed to the camp by the four wives of Osman *Beg*, who brought a gift of a kind of puff pastry, made with cream. They looked most picturesque in their flowered chintz coats padded with cotton, and their long leather boots. Their headgear, composed of rolls of muslin wound on a wooden frame, were striking. They wore necklaces of red coral and silver, with long pendants, and some of them had silver buttons and clasps on their coats of fine Bokhara work.

They were extremely friendly and much enjoyed tea with sugar (instead of salt), biscuits and sweetmeats, large quantities of which had been laid in for the purpose. As they made no objection to men being present, my sister was able to talk freely with them through the servants. Indeed some of them knew a little Persian. The general impression was that their lives were very hard, owing to the nine months of cold weather. They also work from morning to night, what with milking the herds, rearing the children, weaving homespun cloth, shifting camp and cooking. They were a plain weather-beaten lot, but some of the children were charming.

Women are highly prized, as there are not enough to go round. The rich men marry four wives, and so the poorer members of the community are placed in a difficult position. Wives are purchased, but the hundred sheep that constitute the minimum price are counterbalanced by the dowry of the bride, in the form of jewelry, household stuff and live-stock. The wedding customs are primitive. When the suitor has been accepted and has handed over his sheep, the father-in-law gives a feast, at which neither the bridegroom nor the bride appear. Late at night the *jinai*, or matchmakers, who play an important part in these ceremonies conduct the bride, who makes a show of resistance, to a separate *akoi* that has been specially decorated for the occasion. The bridegroom then stealthily approaches the nuptial *akoi*, where he is greeted by the *jinai* with " barking " and, at first, hindered from entering to greet his bride. The bridegroom leaves before dawn, as he is taboo for that day to his father and mother-in-law. The final ceremony is accomplished when he carries off his bride to his own camp. The mother and her relations mourn over her departure, she offers some resistance, and is carried off with a considerable show of force.

Under the guidance of Osman *Beg*, we marched west to the foot of the Katta Dawan or " Great Pass," beyond which lay the " Roof of the World." Owing to the deep snow that we were likely to experience on the pass, we arranged to use yaks. These " grunting oxen," as they are termed, from their habit of grunting like pigs, are remarkably sure-footed, and can go up and down places that are too steep for mules or ponies. They can also support the most severe cold, and are accustomed to dig down to their grazing through the snow. They are docile with the Kirghiz, but are savage with Europeans, as I found out when I was chased by one many years ago in Tibet.

We loaded up very early, and the sky was clear when we started, although a good deal of snow had fallen in the night. The ascent was very steep and our mounts were soon plunging through the deep snow. We could not see the narrow track, but a Kirghiz on foot guided us, being aided by the fact that if he left the beaten path, he sank immediately up to his waist in the snow. At times the track lay along the edge of precipices. As we ascended many members of the party began to suffer from mountain sickness. One Kirghiz threw himself down and sobbed as if his heart would break. He then set up a dismal howl and staggered off downhill, in spite of the jeers of his relatives and friends. Clouds had been gathering ominously and we reached the summit of the pass at an altitude of 16,000 feet in a storm that completely blotted out the landscape. The guide became very anxious, as we had to cross a plateau and no landmarks were visible. We moved forward very cautiously, when suddenly a gust of wind swept away the snow for a minute and revealed to us a most wonderful sight. We were passing among a group of mighty snow giants, with a glacier of green ice glistening in the sun. Looking forward our view ranged far over low hills flecked with snow, while apparently at our feet the dark blue waters of the Great Karakul Lake completed a picture that time will never efface from our minds. The snow changed into sleet as we began the descent of the pass, but there was now no fear of losing the way, and I was able to congratulate my sister on being the first European lady to cross this formidable pass which had brought us to the " Roof of the World," the land of our dreams.

The descent was difficult, but in our joyous mood we made light of the floundering and tumbling in the deep snow. The weather, too, improved as we descended, and when we reached a running stream, which watered a charming

Alpine garden, we decided to halt, and much enjoyed the hot tea from our thermos flasks, for we had been many hours crossing the Katta Dawan and were thirsty and tired.

We descended the valley in radiantly bright weather, and enjoyed the sun and the wonderful views across the lake to the great Trans-Alai Range, which stood up grandly with its dazzling white mantle of freshly fallen snow. When, at sunset, we reached the gravelly waste surrounding the lake, we were shown a group of *akois* in the distance, but suddenly a violent sandstorm blotted out the landscape, and it was a very dirty and tired party, with badly-swollen faces, that finally stumbled into an *akoi*. Some hours elapsed before the caravan arrived, but at last the slow-moving yaks appeared, and, before midnight, everyone had settled down after a very long but intensely interesting march.

From the borders of the lake we travelled ninety miles to the Russian centre of Pamirski Post. Although it was midsummer we started off in a foot of snow. After a while the sun shone fiercely, wraps were discarded, and when we halted at midday, the snow had disappeared and the heat was intense, so that we longed in vain for the shelter of a tree or even of a rock. Suddenly there was a peal of thunder in the mountains, and a short, sharp shower fell from the cloudless sky. Then an icy blast blew until we agreed that the sunshine in the Pamirs was sometimes "iced." At night it was invariably very cold, and we enjoyed wearing long boots and woollen caps, while plenty of bedding was essential. The altitude, which was higher than that of the average peaks of the Alps, made us feel disinclined to take unnecessary exertion. Running, for example, would have been almost impossible. My sister always felt that an invisible hand was clutching her throat, and a general lack of fitness and loss of appetite were experienced by us both, which passed away entirely when we descended from the Pamirs to nine thousand feet.

It is curious that, in one of the coldest countries in the world, there are no houses. The fact is that the people live on the products of their flocks, and are, therefore, obliged to change their poor grazing grounds constantly. Moreover there is no agriculture whatever, and a piece of bread is a rare luxury. In spite of the absence of "the staff of life," and of vegetables, everyone appeared to be well fed and healthy. It is probable that the strong alone survive.

We took a photograph of the only building we saw. It was a roughly-constructed shrine, in which was buried a mighty hunter. My tracker, Nadir, prayed at it that we should make a good bag and concluded by solemnly opening a cartridge and spilling the cordite over the tomb.

We hardly met a traveller on the track running from the lake to Pamirski Post which was passable for carriages, and almost the only things of interest that we noted were sea shells in the mountains, thus proving that the "Roof of the World" was at one period under the sea

Outside Pamirski Post we were first met by two *Mingbashis* or "Commanders of a Thousand," gorgeous in purple robes, handsome Bokhara belts with rich silver mountings and snowy turbans. Like other leading officials they spoke a little Persian, and were delighted to air their knowledge of the "French of the East."

We were warmly welcomed by the Russian Commandant, and much enjoyed rest for a day or two. We were disappointed at the miserable barracks that had been erected for the men, whose lives in the winter must be very trying. Fortunately they love dancing the quaint Cossack dances, which take the place of the games which keep the British soldier fit. The stables, too, were dark and badly ventilated. There was a squalid bazaar, where a few traders lived during the summer, but, generally speaking, Pamirski Post was a most depressing spot.

One object of the journey was to hunt the *ovis poli*, which had been my cherished ambition for many years. The first mention of this splendid ram was Marco Polo's account of "wild sheep of great size, whose horns are good six palms in length." A palm is reckoned to be ten inches, so Marco describes horns five feet in length, nor did he exaggerate, for the record head is longer than that. These superb beasts stand twelve hands and weigh about 22 stone.

It was midsummer and about the worst time for hunting, as, owing to the heat and the insect pests, the game hid during the day in the highest and most inaccessible parts of the range. At night, however, they descended into the valleys, and there was a chance of intercepting them when returning to the mountains. We camped in a shallow valley, and starting off two or three hours before dawn in bitter cold on yaks reached the snowline before daylight. We carefully hid the yaks, and then watched the valley, sweeping it incessantly with our glasses. On one happy day we spied a small herd with a fine ram slowly grazing its way uphill. The stalk was difficult among the boulders, which gave but little cover, but a lucky shot secured me the blue riband of the chase. On another occasion I wounded a ram and was able to run it down with dogs.

Kipling gives the spirit of the sport in the lines:

"It is there that I am going, where the boulders and the snow lie,
With a trusty, nimble tracker that I know,
I have sworn an oath, to keep it on the horns of *ovis poli*,
And the Red Gods call me out and I must go."

We left the Pamirs by an easy pass, the ascent being short, whereas the descent was interminable. However, as we descended, so the feeling of lassitude passed off, until at Tagharma we experienced the mere joy of living to the full. It was delightful to stroll about among sheets of mauve primulas, white and pale blue anemones and pretty little blue daisies, and to see the green meadows stretching for miles in every direction.

The Kirghiz chiefs arranged an exhibition of the game of *baigu*, or "hunt the goat," for our amusement. The "ball" is prepared by killing a goat, and after its head had been cut off, its bones broken and its entrails removed, it was carefully sewn up. The Kirghiz, mounted on their wiry ponies, formed a *mêlée* and tried to pick up the goat which was thrown among them. After much shoving, one man succeeded and, tucking it under his thigh, rode off as fast as he could urge his mount, pursued by the others. If he rounded a flag and reached the starting point with the goat, he was awarded a silk handkerchief. Sometimes there were fierce struggles, the players becoming wildly excited. The ponies, which were grass-fed, gradually became exhausted, and so we thanked the competitors for the exhibition of the national sport and brought it to a close.

The Sarikol Valley possesses the extraordinary interest that its inhabitants are pure Aryans, the last link in the long chain that now stretches across the world from California, through Europe and Persia to Afghanistan, and through Badakshan, to the Sarikol Valley. The people, with their aquiline noses and clear-cut features, have little resemblance to the mixed population of Chinese Turkestan, and none whatever to the flat-faced Kirghiz. Rather they might be taken for inhabitants of South Europe.

Although not British subjects, they are followers of H.H. the Aga Khan, and travel across the most stupendous mountain barrier in the world to Bombay, to pay their respects to their religious head and to offer him tithes. They speak Persian, and as they were aware that I was a friend of His Highness their welcome was extremely cordial.

After the desolate Pamirs it was delightful to see crops of wheat, barley peas, alfalfa and mustard once again, and even the rough homesteads gave one the impression of civilisation. At the same time these crops mature with great difficulty and are distinctly scanty.

The Sarikolis cherish the legends of Iran and have given their mountains the old familiar names. They were never tired of talking about the history of Persia and said that their chiefs had emigrated to the valley from Badakshan five or six generations ago. There were two leading families, which had long been on bad terms with one another, mainly owing to rivalry as to which had the privilege and the profit of collecting the tithes. I heard a great deal about this feud, and pointed out that for a small colony of Aryans to quarrel among themselves only helped their enemies. This point of view finally appealed to their leaders and, before I left, a reconciliation took place, clinched by a feast and intermarriage. In their courteous way, they said that they offered me their reconciliation as a gift.

The Sarikol Valley is situated about halfway between Gilgit and Kashgar, between which centres the Government of India maintains a postal service, carried by runners. Among the interesting visitors I received was the postmaster, a brother of the *Thum*, or Chief, of Hunza, who rules over the Kunjuti tribe and claims descent from Alexander the Great. Nor is the claim fantastic, for his family has intermarried with the chiefs of Badakshan, the classical Bactria, and the seat of a Greek dynasty which ruled the country for some two centuries after its conquest by Alexander the Great.

The Sarikolis are devoted to singing and dancing, and we much enjoyed the performances of a troupe of youths led by a band consisting of a drum and pipes. They sang many songs, interspersed with dances, and we only regretted that lack of time prevented us from studying and collecting their songs. The "star" performer was a boy, who executed most graceful steps, waving his long sleeves in the most effective manner as, indeed, they all did. We were informed that, nowadays, the old people alone remembered the songs relating to raids and fighting, and that the present generation only cared to listen to themes of love and feasting—so soon do altered conditions react on the rising generation.

Their favourite chorus ran :

> " Alas ! my unfaithful love.
> Alas ! my inconstant heaven.
> I grow thin as a blade of grass
> In my craving for thee."

I shall never visit the Pamirs again, but I sometimes dream that I am on the " Roof of the World," and see my patron saint, Marco Polo, marching across its lonely wastes and wondering at the size of the mighty rams that were destined to be called after him. Or again, I am in the Sarikol Valley and, sitting in an *akoi*, I hear one group singing " Thy cheeks are like tulips," to be answered by the second group with " Thy eyes are dark as spring-water," These are the memories that remain.

DISCUSSION.

MISS ELLA SYKES said that whenever she had had the good fortune to be in the East she had always been interested in the position of the women, and it seemed to her that in Chinese Turkestan they had a much better time than their Persian sisters. It was very pleasant to see the women riding into market near Kashgar, managing their horses perfectly and driving their sheep and goats. Of course they had their little square face veils, but these they seldom put down except in the towns or on the occasions when they saw her brother ! But there was another side to this picture, as she found out later on. Men migrated in great numbers into Russian Turkestan, where the pay for labour was much higher than in Chinese Turkestan, and this caused a great surplus of women in Kashgar, with the result that the degrading custom of temporary marriages with the traders was in full force. The mullah actually performed the marriage ceremony and gave the bill of divorcement at the same time. Divorce was very cheap, equal to about fourpence in English money. In the Russian Pamirs the conditions were very different ; there the women were so much in the minority that wives were expensive. The stalwart Kirghiz came constantly into Kashgar to sell their cattle, but never took back brides, evidently realising how useless the pretty Kashgar girls would be as wives on the " Roof of the World." The Kirghiz women impressed her most favourably. There a man with many daughters was looked upon as a fortunate fellow. Every now and then an eligible suitor appeared, though not rich in worldly goods, and served his would-be father-in-law for a term of years, just as Jacob served for Rachel centuries ago. He married the girl of his choice, and at the end of his term of service the father fixed up the young couple with a home and live-stock. Throughout her time in the Pamirs it struck her that the women did all the work and the men had all the play. The men were constantly playing the " goat game," and also riding off to marriage or funeral feasts, where there were horse races and prizes. The women had to look after the flocks and herds, to make the cream and the cheese, to see to the children, to make the clothes, and to do the cooking at the feasts. The women had also to make the felts for covering the bee-hive dwellings, and the carpets to cover the floors, and on one occasion she saw a woman putting up the willow laths which formed her home. In fact the Kirghiz women reminded her of the lady mentioned in the Proverbs whose price was above rubies.

MR. CLARMONT PERCIVAL SKRINE, I.C.S. (Political Officer) said that he was extremely grateful to the Council of the Society for giving him the opportunity of saying a word about this exceedingly interesting paper. He had never seen anything so fine as the lantern pictures and having himself recently come from that part of the world, he could testify that the tints were by no means exaggerated. The pictures gave an extraordinarily good idea of the country, especially of Kashgar and the plains. The Pamirs were more difficult, because they had less colour. He had had the honour of being acquainted with the distinguished lecturer since 1918, when he (the speaker) was Consul at Kerman, and Sir Percy, who was then Inspector-General of the South Persia Rifles, came over to that place from Shiraz for two or three weeks ; and he well remembered in those days Sir Percy speaking very highly—in glowing terms, in fact—of Kasghar and Central Asia, where he had not long before been acting as Consul-General for about a year. Later an opportunity came to the speaker to go there himself when he was offered an appointment of Consul-General, and he jumped at the chance. His wife and he went there in 1922. Before very long he was able to discover that Sir Percy's taste in billets was very good, and he and his wife were extremely happy during the two and a half years they were in that fascinating country. There were any number of points in the lecture which brought back memories to him, but it would take too long go dwell on them. There were one or two things he would like to tell the lecturer about in particular, including the present well-being of some members of the entourage of whom he had spoken. Jafar Bai, of the Consulate staff, whose picture Sir Percy had shown, was now living in retirement on large estates ; he was quite a rich man. Another, the stalker, Nadir Beg, was a tower of strength to the British cause. Tall and extremely handsome he had a delightful turn of humour, as Sir Percy had mentioned. A friend who was travelling with him (the speaker) had come from Ceylon, where it rained a great deal, and thinking it was going to rain in the Pamirs he put an oiled silk cover over his helmet. One day Nadir Beg told the speaker with much glee that his little son had asked him why the sahib always wore a lamb's " tummy " on his head ! The lecturer had mentioned the " Commanders of a Thousand " in the Russian Pamirs. The speaker was interested while crossing the Chinese Pamirs to be called on by a certain man who was an exile from Bolshevik Russia and was squatting with his family and his flocks and herds in the Chinese Pamirs. He had asked him (the speaker) if he knew the great sahib who came with the lady about ten years ago—this, of course, was Sir Percy Sykes with Miss Ella Sykes. He had very pleasant recollections of his acquaintanceship with them. The lecturer had showed a picture of Kurghan Tim, the ancient Buddhist ruins which were visible from the Consulate-General. These were being rapidly destroyed by cultivators near by, who were using them as a sort of quarry for clay. He had arrested the course of destruction by complaining to the local governor and asking him to order the local cultivators not further to destroy these mounds. Sir Percy Sykes had mentioned the Chinese name which appeared on his visiting card, and which, it was required, should have three syllables. The speaker was succeeded by Colonel Robert Lyall, for whom also it was necessary to find a Chinese name so that the large red visiting-cards might be ready for his arrival. The speaker and his Chinese Secretary put their heads together and eventually settled on a three-syllabled name which they thought had a good meaning; but when he showed the governor and his secretary what was proposed, he was told that it would not do at all; the newly chosen name, pronounced a certain way, signified: "A strong man who refuses to pay his debts." After another day or so of cogitation a revised form was thought of, which meant—they told him—"A pure dwelling upon a high mountain in Szechwan," a strange name for an official, but a very lucky one.

Dr. Arthur Haydon said that he had gathered from the lecturer that one of his excursions was seriously interfered with by mountain sickness. This, however, was quite easy to treat. The curious feeling of constriction at high altitudes also could be remedied. The remedy was to carry oxygen. He wondered whether Sir Percy had used that expedient.

Sir Percy Sykes said that it must not be assumed that any of the party died through mountain sickness. All that happened was, that when he turned back, they lost this young man's society, and his mother gained it. One remark of the last speaker rather reminded him of the reply given by a traveller who was asked why he did not have this, that, and the other on his travels in Central Asia. He replied, "You know, Central Asia is a place where the waiters do not wear white ties"! While travelling, in war-time especially, one had to go extremely light. It was not possible to carry cylinders of oxygen.

Colonel Sir Charles E. Yate, Bt., C.S.I., C.M.G., remarked that Sir Percy Sykes had referred to the sport of deer hawking. But his (the speaker's) experience of it was, and he had tried it pretty often, that the hawks, which always had dogs with them in hunting deer, would never go near the buck, because they were afraid of being impaled on the horns. They went for the smallest doe they could find in the herd, so that the sport did not amount to much. He wished to congratulate the lecturer on his beautiful pictures. The colours were perfect, and altogether the photographs were the most marvellous things of the sort that he had seen.

The Chairman said that he was never in Kashgar, but as a young man when Assistant Commissioner in Kulu and in charge of the trade route as far as the Bara Lacha Pass, and again as resident in Kashmir, he saw a great deal of the Central Asia trade, and it had been the greatest pleasure to him to see these beautiful pictures and to hear the most excellent account of the country by Sir Percy Sykes and Miss Sykes. He was afraid Miss Sykes had not spared men. He had said at the beginning how fortunate men were to have wives and sisters who did all the work and left the men all the play, and Miss Sykes had drawn attention to the fact that this was also the case in the East. When he was in Spiti, south of Khotan, he found much the same sort of thing as in the Pamirs. There the average elevation of habitation was some 12,000ft. and the cultivation depended on very scanty supplies of water. Most of them would have heard of a thing called polyandry. Some people had advocated it in this country. It was the principle that a lady might have more husbands than one. But in the part of Thibet alluded to there was polyandry and polygamy flourishing in the same country, which was rather curious. If a man had a fairly big holding and there was only one brother he had as many wives as were necessary adequately to cultivate the holding. If, on the other hand, there were five or six brothers and a small holding, some of the brothers became lamas, at any rate for a time, and the others all married one wife between them and took their turns of travel and home life. All the children, however, were children of the eldest brother. He had asked whether quarrels ever arose owing to the lady taking a fancy to one particular brother, and the reply was that if this ever took place this brother became obnoxious to his brethren and was sent away for a long period of travel. The lecturer had spoken of the manner in which the silkworm seed was brought to the west. In 1897 it appeared that the silkworms in Kashmir and in Northern India had died out owing to pebrine, and the whole industry was doomed. Then it was decided to bring disease free silkworm seed from the West to the East. It was now imported at the rate of £6,000 worth of seed a year, and the Kashmir industry, as a result, was now flourishing, with some 20,000 rearers, who received for their cocoons more than twice the total revenue of the valley, 8,000 persons in the filatures, which more than made good the loss of the old shawl trade. The profit to the State was usually about £50,000, and he thought, during the war, the Darbar made £100,000 a year profit from this valuable State industry. The lecturer, on the picture of a Nagar chief, had referred to the very handsome Caucasian types to be found in those parts. That held good of the upper Aryan classes amongst the hillmen generally. Sir Percy thought they were representatives of Alexander's Greeks. It was possible, though a pure Iranian descent was perhaps enough to explain the recurrence of such types. He did not mention the case of the Kafirs just south of the Hindu Kush, who actually claimed to be the descendants of the Greeks. Some of these were fair and good-looking, and their principal god appeared to be an admixture of Dionysus and Ares. It was curious that Alexander had heard rumours of Greeks or worshippers of Dionysus in those parts, who grew vines and drank much wine as the Kafirs do. These interesting people in their remote glens, now mostly converted to Islam, might have been the descendants of an earlier Greek incursion of which the memory was kept alive by the myth of Dionysus' visit to India. The lecture had been one of the most interesting he had ever listened to, and he proposed a very cordial vote of thanks to Sir Percy Sykes.

SIR EDWARD A. GAIT, K.C.S.I., C.I.E., in seconding the motion, said that it was always a great pleasure to get first-hand information regarding countries of which one had no personal knowledge and that pleasure was increased when the countries were of such romantic interest and when the lecturer was so well equipped for his task. He would like to include in the resolution thanks to Sir Louis Dane for very kindly coming, at short notice, to take the Chair.

The motion was carried unanimously.

NOTES ON BOOKS.

HISTORIC INSTRUMENTS FOR THE ADVANCEMENT OF SCIENCE. By R. T. Gunther.
Humphrey Milford: Oxford University Press. 2s. 6d. net.

This handbook to the Oxford collections was prepared for the opening of the Lewis Evans collection in May last, and is in some respects a brief abstract of the author's three volumes, *Early Science in Oxford*. The Museum, which owes its foundation and many of its rarest contents to "that excellent and publick-spirited Gentleman, Elias Ashmole, Esquire," is peculiarly rich in scientific instruments; for instance, it possesses a notable collection of astrolabes, including a Persian instrument dated A.H. 374 (=A.D. 984), which is actually the earliest dated scientific instrument known, and also fine sets of Persian, Indian, Egyptian, Moorish, Spanish, Italian, French, Flemish, German and English astrolabes.

An early ancestor of the taximeter is shown in Cary's perambulator or "way-wiser," of which the first record appears in Evelyn's *Diary* of 1656.

Some remarkable telescopes are now in the collection, including replicas of Galileo's instruments, and one of the oldest extant micrometer eyepieces; but possibly the most interesting entry in the catalogue is that referring to the Hooke Microscope. Robert Hooke, of Christ Church, invented an entirely new method of supporting his microscope, by mounting the body-tube and screw-collar upon a pillar, with a ball-and-socket movement so as to render the tube inclinable. His method has been universally adopted ever since, and it enabled him by examining a specially prepared section of vegetable tissue to see, for the first time in the history of mankind, cells—to observe, in fact, that the particular tissue at which he was looking consisted of nothing but cells, thus originating "perhaps the most important generalisation ever made with regard to the structure of living things." His instrument and discovery were communicated to the Royal Society in 1663, and he then described what is probably the first occasion on which a microscopic section was cut.

A SYSTEM OF PHYSICAL CHEMISTRY. By William C. McC. Lewis, M.A., D.Sc. Volume II.: Thermodynamics. Fourth Edition. London: Longmans, Green and Co. 15*s*. net.

It is not given to every text-book to attain the rank of a classic within a few years of its original publication, but such a claim might fairly be made on behalf of the present work. Admittedly, the competition has not been very severe, being practically limited, so far as concerns books on advanced general physical chemistry published in this country, to the earlier works by Nernst and Ostwald and the recent treatise edited by Taylor; but mere scarcity of competitors, unaided by a high degree of intrinsic merit, would never have provided the reputation which Lewis's text-book has won.

The second volume, which now appears in its fourth edition, is that which deals with the application of thermodynamics to chemistry; the first is occupied with the mechanistic treatment, and the third with the quantum theory. As Professor Lewis explained in his original preface, this division is not the result of any theoretical principle of classification, but is adopted in order to make the book more easily readable. It is undeniable that a certain inconvenience results at times, but probably not more than would attach to any other method of presenting the subject.

The main improvement incorporated in the new edition has been the provision of an outline of the activity concept. This was badly needed, and might even be considered somewhat overdue. In this section, as elsewhere in the book, actual extracts from the original papers are given on occasion, with the effect, of course, of lending additional authority to the account presented. In principle, having regard to the different functions performed by an original paper and a text-book, it might perhaps be thought that this practice would prove undesirable, since it could hardly be expected that the same form of words would be the best possible for both purposes; and, no doubt, this would give rise to a real objection were not the most careful judgment used in the selection of passages for quotation.

Although the greater part of the book is obviously intended for post-graduate workers, yet there is much in it which might with advantage be assimilated by the undergraduate honours student, provided he can avail himself of sound guidance in choosing his reading.

THE MECHANICAL INVESTIGATIONS OF LEONARDO DA VINCI. By Ivor B. Hart. London: Chapman and Hall, Ltd. 16*s.* net.

In this delightful volume, with its seven inset plates and 136 illustrations in the text, Mr. Hart calls special attention to Leonardo as the chief pioneer and student as regards the kinematics of flight, but he also gives his readers a pleasant introductory story of Leonardo as the many-sided genius of the Renaissance (pp. 1-54).

Like Machiavelli, his contemporary and fellow Tuscan, Leonardo failed to gain the advantages of printing as a means of giving publicity to his writings, the printing activities of his period being mainly devoted to multiplying the more ancient literature, but we possess the more important of Leonardo's physical and mathematical writings actually as he produced them; notes and sketches being side by side on the same sheet. The chief collection of such sheets, known as the *Codice Atlantico*, embodies some 400 sheets and nearly 2,000 marginal sketches. It has been recovered after many wanderings, and, together with minor items, has been safely placed where available for use and reference (pp. 194-199).

Mr. Hart gives us an English version of all Leonardo's known matter relating to the flight of birds and on immediately collateral mechanical and mathematical subjects, while thin sheets of original text with marginal sketches are reproduced in *fac simile;* these forming plates V, VI and VII. The work under notice abounds in lucid descriptions of mechanical detail, and manifestations of historical study, all being pleasant to read and easy to understand.

It is difficult to select representative samples of a work like that before us, but we may mention Leonardo's scheme for a vertically rising flying machine as figured on p. 192, and in addition the author shows that Leonardo clearly understood the essential principles of the fire balloon (pp. 150-151) and of the parachute. Conjectures seem vain when we try to penetrate the dim vistas of the far past, but we may take it that the matter now presented to the reader stands on a very firm documentary basis, the writings and sketches being undoubtedly from Leonardo's own hand in or about the year 1505. The general reader may think of many things which have been suggested by his reading, and regarding which we can have but little hope of knowing the basis of truth, if any; as, for example, the story of the flight of Bladud, or that of Icarus.

GENERAL NOTE.

INDIA OFFICE LIBRARY.—The annual report on the India Office Library for the financial year 1923-24 shows that the number of readers was 2,673, while 2,019 books were taken away on loan and 72 MSS. and Xylographs were also lent. The accessions, including periodicals, amounted to 10,053. In addition eleven manuscripts (five Sanskrit, five Tibetan and one Persian) were purchased. The entries under the same heading mention an English framed letter (9/6/1732) from Mr. Daniel Bayley to the Rev. Mr. King, of Styche, concerning Clive's boyhood. This was presented by the late Sir Steuart Colvin Bayley. Amongst the donations were the following:—Five seals in Nāgarī character and six in Persian character, and eighteen gramophone records of languages spoken in the Bombay Presidency.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

REPORT ON THE COMPETITION OF INDUSTRIAL DESIGNS, 1925.

INTRODUCTION.

This competition was held for the first time in 1924, when 1,408 designs were submitted by 553 candidates. On the whole, the judges were disappointed in the quality of the work submitted last year, but in some sections, especially Textiles, a number of good designs were shown. One case, in particular, the Council have much satisfaction in placing on record. The student who won a Travelling Scholarship of £50, for black and white work, after visiting Holland, was placed in communication with a first-class printing firm, and he has since been kept in almost continuous employment carrying out illustration work of a high order. His introduction to this class of work was entirely due to his success in the competition.

The Council are also gratified in reporting that the competition has been brought to the attention of the Board of Education, who have formed a very high estimate of its practical value. They believe it will have a far-reaching and useful influence upon the teaching in schools of art throughout the country, and in order that they may be kept in touch with the movement they have appointed Mr. Harvey Allport, H.M. Inspector of Schools of Art, to serve on the Central Committee of the Scheme. The Council warmly welcome the prospect of this co-operation with the Board.

As was explained in last year's report, in order to add to the attractiveness of the competition, it was decided to offer money prizes, and, if possible, travelling scholarships. Accordingly the various sectional committees issued appeals for funds, to which very satisfactory responses were received. The list of subscriptions is printed as an Appendix to this Report.

PARTICULARS OF THE COMPETITION, 1925.

Particulars of the present Competition were issued and widely circulated at the end of 1924. The announcement of the subjects and prizes was as follows :—

OPEN COMPETITION OF INDUSTRIAL DESIGNS.

In order to encourage the study of designs for industrial purposes, the Royal Society of Arts have decided to hold Annual Competitions. The second Competition will take place in June, 1925. It will be open to two classes—(*a*) All British Subjects (with certain specified limitations as to age in the Sections of Architectural Decoration and Furniture), and (*b*) Students in British Schools of Art.

Entries can only be received from individual designers, not from firms.

The subjects of competition will be the same for both classes of candidates, but in considering the work the Judges will bear in mind to which class the competitors belong.

The Competition will be divided under the following heads:—

(1) Architectural Decoration.
(2) Textiles.
(3) Furniture.
(4) Book Production.
(5) Pottery and Glass.
(6) Miscellaneous.

Particulars of the subjects prescribed in each Section, together with the prizes offered in connexion therewith, will be found below. The Council reserve the right of withholding any or all of the prizes offered, or of awarding prizes of less value.

Designs for which prizes are not awarded may be "Highly Commended" or "Commended" at the discretion of the Judges.

The Judges will be appointed by the Council of the Royal Society of Arts on the recommendation of the various Sectional Committees. *In making the awards, it shall be an essential condition that the designs approved are suitable for the materials for which they are intended.*

The Society will confer its Diploma on any candidate whose work shows exceptional artistic ability and practical knowledge of the materials and processes of his trade.

The following are the subjects of competition in the various sections in 1925:—

ARCHITECTURAL DECORATION.

Decorative Architecture.

A Travelling Scholarship of the value of £150 for one year will be offered on the following conditions:—

> Candidates must not be over 35 years of age. They must be prepared to travel in France, Italy, Spain or Flanders for six months, which, however, may be broken up into periods of, say, three or two consecutive months.

Subject of Competition.

The subject is a Memorial Library for a College, suitable for housing a small but rare collection of books.

The superficial area of the room is not to exceed 1,500 feet. The method of arranging the bookcases and displaying a few *objets d'art* is left to the competitor. Cost is not a primary consideration, and the use of expensive woods, as well as inlays of ivory, ebony or metal, in addition to marble, can be considered.

In a suitable place a commemorative panel or some other *motif* should remind the visitor of the origin of the Library. The scheme of the ceiling, which can be treated as a space for decorative painting, as well as the pattern of the floor, must harmonise with the whole design.

A preliminary competition of twelve hours will be held in London and other centres in April, 1925. Candidates must give notice of their intention to compete, to the Secretary of the Royal Society of Arts, not later than March 14th. For this competition the following drawings will be necessary:—

> A plan of the floor, one section, and a plan of the ceiling, all to a scale of a quarter of an inch to a foot.

For the final competition two months will be allowed to the competitors, selected after the first competition. The finished drawings are to include the following:—

> Plans of floor and ceiling and two sections to a scale of half an inch to a foot, a detail drawing of the fireplace or some other feature shewing the complete height and treatment of the room from floor to ceiling.

Competitors should bear in mind that electric lighting and central heating are to be considered.

Wallpaper.

The subject of competition is as follows:—

> A design for a Wallpaper suitable for use in large panels in a Theatre or Cinema, to be reproduced by Block Printing in not more than four colours. Size, 42 ins. repeat by 21 ins. wide.

Prize offered: A Prize of £10 10*s*. is offered for this subject.

TEXTILES.

The subjects of competition are designs for the following:—

(1) Carpets and Rugs; Moquettes; Floor Coverings; Linoleum and Floor Cloths.

(2) Tapestries; Damasks, Brocades and Figured Velvets for Furniture and Decoration; Vestments; Church Fabrics, including Altar Frontals, etc.; and Table Damasks.

(3) Printed Fabrics for Hangings and Furniture; Bedspreads; Cushion Squares; Tea Cosies, etc.

(4) Printed Fabrics for Dress; Dress Brocades and Fancy Dress Fabrics; Handkerchiefs; Tie Silks and Mufflers; Ribbons and other narrow goods.

(5) Lace; Lace Curtains; Embroidery; Open Work.

Candidates may submit designs for any or all of the items in any or all of the foregoing groups.

Prizes offered: The contributions to the Prize Fund are sufficient to allow of the award of one, or possibly more, Travelling Scholarships to candidates of outstanding ability. The course of study to be followed by the successful candidates will be decided after consultation between them and the Judges.

Money Prizes of not less than £10 10*s*. each are offered in each of the groups (1)—(5) at the discretion of the Judges.

FURNITURE.

The subjects of competition are as follows :—

(1) Designs for the complete Furniture of a Dining Room decorated in 18th Century Period.
(2) Designs for the complete Furniture of a Bed Room, decorated in William and Mary Period.
(3) Designs for the complete Furniture of a Study, without reference to traditional style.
(4) Designs for the complete Furniture of a Working-man's Living Room.
(5) Design for a Cabinet for Decorative China.
(6) Designs for Writing Table and Chair.
(7) Designs for Garden Furniture in Cane.

Prizes offered : A Prize of £20 is offered for the best set of designs in each of the groups (1), (2) and (3), and a Prize of £10 10*s*. for the best designs in each of the groups (4), (5), (6) and (7). Second Prizes may be awarded at the discretion of the Judges.

No Candidate may receive more than two First Prizes.

Candidates in this Section must not be over 25 years of age.

BOOK PRODUCTION.

The subjects of competition are as follows :—

(1) Designs for either or both of the following :—(*a*) A Title Page entirely set from Type, with or without Printers' ornaments ; (*b*) A Title Page partly decorated. The Title Pages to be taken from any or all of the following :—
  (*a*) " The History of Tom Jones, a Foundling," by Henry Fielding. (Size, Demy Quarto.)
  (*b*) " On the Morning of Christ's Nativity," by John Milton. (Size Crown Quarto.)
  (*c*) A Scientific Paper. (Size, Demy Octavo.)
  The copy in each case will be supplied by the Royal Society of Arts.
(2) Designs for Three Pages of Text, with Chapter Heading, from any or all of the books enumerated in Section 1 above, and in the sizes respectively indicated there.
  The copy for (*c*) will be supplied by the Royal Society of Arts.
(3) Designs for *either* (*a*) A Line Illustration, or (*b*) A Colour Illustration.
  (The subject of the design must be taken from a well-known book, *e.g.*, one included in the *World's Classics* or *Everyman's Library*.)
  The design may be drawn to any size, but must be suitable for illustrating a Crown Quarto page.
(4) An all-over design suitable for general use as *either* (*a*) an End-paper, or (*b*) a Cover Paper. N.B.—Paper Jackets are not eligible.
(5) Design for a Binding for " The History of Tom Jones, Foundling," by Henry Fielding, in Cloth (blocked).
(6) Design for a Binding for " The History of Tom Jones, Foundling," by Henry Fielding, in Leather (tooled).

All designs must be submitted on Paper, and not as finished articles.

Prizes offered : A Prize of not less than £10 10*s*. is offered for each of the subjects set forth above.

POTTERY AND GLASS.

The subjects for competition are as follows :—

China.

(1) Designs for a Tea Cup and Saucer and Cream Ewer, with decoration suitable for either engraving, enamelling or lithographing; with or without gilding, and with or without grounds.

Earthenware.

(2) Designs for a Dinner Plate and Vegetable Dish, with decoration suitable for either engraving, enamelling or lithography; with or without gilding.

Glass.

(3) Designs for a Service of Glass (*i.e.*, a Wine Glass, a Tumbler and a Decanter) in plain form or with decoration suitable for etching, engraving or cutting.

(4) Designs for a Water Jug, Goblet and Salad Bowl, in plain form or with decoration suitable for cutting.

(5) A design for a Dish or Bowl in pressed glass.

In this Section candidates are earnestly advised to aim at beauty of outline rather than elaborate detail.

Prizes offered: First Prizes of not less than £10 10*s.* each will be offered in connexion with each of the groups (1)—(5). The copyright of the designs will remain the property of the successful candidates, who will also be afforded special facilities for selling their designs to the Manufacturers' Associations interested.

MISCELLANEOUS.

CADBURY BOURNVILLE TRAVELLING SCHOLARSHIP.

Messrs. Cadbury Brothers, Ltd., offer a Cadbury Bournville Travelling Scholarship of £50 for one year in each of the years 1925-7. The winner will be required to travel on the Continent of Europe for the development of his or her art.

The subjects for competition are :—

(1) A Poster drawing attention to the Value of Cocoa for Children.

(2) A Poster advertising Chocolate.

Candidates may enter for either or both of the foregoing subjects.

The award will be subject to the under-mentioned conditions :—

(*a*) The Judges shall be three in number, of whom two shall be appointed by the Royal Society of Arts and one by Messrs. Cadbury Brothers, Ltd.

(*b*) The Scholarship-winning design, with copyright, shall be the property of Messrs. Cadbury Brothers, Ltd.

SPECIAL PRIZES FOR CHOCOLATE BOX DESIGNS.

Messrs. J. S. Fry and Sons, Ltd., of Bristol, offer two First Prizes of £25 each and two Second Prizes of £10 each for the following subjects :—

(1) A design in four or five colours suitable for a Lid and Front Label for Display Box, including lettering. The design can be associated with any name or title selected by the competitor, design and name being suitable for chocolate assortment boxes. Size not to exceed 11 ins. by 7 ins.

(2) A wrapper in one colour, appropriate to the name of "Somerdale." Size not to exceed 6¼ ins. by 3 ins. Special attention to be given to the style of lettering.

The awards will be subject to the under-mentioned conditions:—

(a) The Judges shall be three in number, of whom two shall be appointed by the Royal Society of Arts and one by Messrs. J. S. Fry and Sons, Ltd.

(b) The prize-winning designs, with copyright, shall be the property of Messrs. J. S. Fry and Sons, Ltd.

(c) The designs submitted must be original, and should be of a character that would be understood and appreciated by the general public.

SPECIAL PRIZE FOR A POSTER FOR SUNLIGHT SOAP.

Messrs. Lever Brothers, Ltd., offer a Prize of £50 for a Poster Design to advertise "Sunlight Soap." The design is to be executed for reproduction by lithography in not more than seven colours. It is to be in the proportion of 16 sheets, and not smaller than 30 ins. by 20 ins.

The award will be subject to the under-mentioned conditions:—

(a) The Judges shall be three in number, of whom two shall be appointed by the Royal Society of Arts, and one by Messrs. Lever Brothers, Ltd.

(b) The prize-winning design, with copyright, shall be the property of Messrs. Lever Brothers, Ltd.

SPECIAL PRIZES FOR POSTERS OFFERED BY MESSRS. NESTLÉ.

Messrs. Nestlé offer three Prizes of £50, £25, and £10, respectively, for Poster Designs to advertise Nestlé's Milk; and three Prizes of £25, £10, and £5, respectively, for Poster Designs to advertise Ideal Milk.

The Designs must be suitable for reproduction by lithography in not more than seven colours. The size must be not less than 30 ins. deep by 20 ins. wide, or in that proportion. Too much detail should be carefully avoided. Great credit will be given for originality of ideas and power to arrest attention.

The awards will be subject to the under-mentioned conditions:—

(a) The Judges shall be three in number, of whom two shall be appointed by the Royal Society of Arts, and one by Messrs. Nestlé.

(b) The prize-winning designs shall be the property of Messrs. Nestlé, including the full copyright, with all rights of reproduction, although there shall be no obligation on the part of Messrs. Nestlé to use them.

SPECIAL PRIZE FOR A DESIGN FOR A CHRISTMAS GIFT BOX.

Messrs. A. and F. Pears, Ltd., offer a Prize of £25 for a design for a Christmas Gift Box containing toilet accessories. The size of the Box is approximately 9½ ins. by 6 ins. by 2½ ins. The choice of the material, metal, wood, etc., is left to the designer, but the wholesale cost of the Box for 10,000 must not exceed £600. The design may, at the option of the competitor, indicate that the Box is a Christmas Gift Box made by A. and F. Pears, Ltd., London. It is not essential to introduce any words, but if candidates decide to do so they are advised to pay special attention to the lettering.

The award will be subject to the under-mentioned conditions:—

(a) The Judges shall be three in number, of whom two shall be appointed by the Royal Society of Arts and one by Messrs. A. and F. Pears, Ltd.

(b) The prize-winning design, with copyright, shall be the property of Messrs. A. and F. Pears, Ltd.

SPECIAL PRIZE FOR "GRAPHIC" COVER.

The Proprietors of "The Graphic" offer a Prize of £25 for a design in three colours, suitable for the Cover of a Christmas number of "The Graphic," on the following conditions:—

(1) The Judges shall be three in number, of whom two shall be appointed by the Royal Society of Arts and one by the Proprietors of "The Graphic."

(2) The prize design, with copyright, shall be the property of the Proprietors of "The Graphic."

(3) The designs submitted should be of a character that would be understood and appreciated by the general public.

(4) The Proprietors of "The Graphic" shall have the right to select any other designs, on the payment of sums of £12 12*s*. and upwards, according to their merits.

"OWEN JONES" PRIZES.

In addition to the prizes mentioned above, the Council offer six Bronze Medals under the "Owen Jones" Trust to candidates in Class (*b*) Students in British Schools of Art.

Thanks to the kind assistance of the Director, Mr. Eric Maclagan, C.B.E., the Society received permission to judge the designs and afterwards to exhibit selected specimens at the Victoria and Albert Museum from August 1st—31st.

NUMBERS OF ENTRIES.

The number of competitors who entered in all sections of the competition was 813. Of these 614 were students of Schools of Art and 188 non-students. The number of designs submitted was 2,033, divided as follows:—

Architectural Decoration Section (including Wallpapers, 37)	48
Textile Section	807
Furniture Section	104
Book Production Section	259
Pottery and Glass Section	103
Miscellaneous Section—	
Prizes offered by Messrs. J. S. Fry and Sons, Ltd.	253
Travelling Scholarship, offered by Messrs. Cadbury Bros. Ltd.	58
Prize offered by Messrs. Lever, Brothers, Ltd.	154
Prizes offered by Messrs. Nestlé	167
Prize offered by Messrs. A. and F. Pears, Ltd.	32
Prize offered by the Proprietors of "The Graphic"	48
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The Schools of Art from which candidates entered were:—

[The number in brackets show the number of candidates from each school.]

Acton and Chiswick (2); Ashton-under-Lyne (1); Barnstaple School of Art (3); Barnstaple School of Science and Art (3); Bath (1); Batley (8); Battersea (21); Belfast (35); Birmingham (4); Birkenhead (1); Blackburn (21); Blackheath (12); Blackpool (3); Black and White Poster Studios (10); Bolton (22); Bombay (1); Bournemouth (1); Bradford (35); Brighton (2); Brixton (1);

Bristol (1); Bromley (Kinnaird Park School) (4); Bromley (Palace School) (4); Burslem (5); Barrow-in-Furness (1); Cardiff (5); Camberwell (3); Carlisle (5); Cambourne and Redruth (2); L.C.C. Central School of Arts and Crafts (50); Chelsea (14); Chesterfield (1); Chester (1); L.C.C., Clapham (3); Colchester (9); Croydon (37); Darlington (10); Darwen (2); Derby (25); Douglas (5); Dublin (5); Dudley (5); Dunfermline (4); Durban (4); Ealing (2); East Ham (2); Edinburgh (15); Epsom (1); Falkirk (2); Falmouth (2); Farnham (30); Folkestone (2); Glasgow (5); Godalming (8); Glossop (7); Goldsmiths' College (34); Great Yarmouth (2); Holywood (1); Halifax (15); L.C.C. Hammersmith (4); Hampstead Garden Suburb (7); Hastings (11); Heatherley's (1); Heywood (4); High Wycombe (8); Hornsey (20); Hove (Wick Studios) (13); Huddersfield (4); Hyde (18); International Correspondence Schools, Kingsway, W.C. (3); Ipswich (14); Keighley (8); Kidderminster (11); Kingston-on-Thames (1); Lancaster (6); Leeds (58); Lewes (9); L.C.C., Lewisham (5); Leyton (12); Liverpool (53); London (Stratford Studios) (1); London School of Printing (3); Macclesfield (18); Maidenhead (5); Manchester (148); Manchester College of Technology (2); Margate and Ramsgate (3); Motherwell (1); Newbury (4); Newport (Mon.) (2); North London Collegiate School (4); Norwich (1); Nottingham (46); Nottingham Correspondence College for Applied Designs (28); Preston (2); Paignton (2); L.C.C., Putney (5); Regent Street Polytechnic (29); Redditch (2); Rochdale (8); Rochester (14); Richmond (11); Royal Academy Schools (6); Royal College of Art (36); Salford (4); St. John's Wood Studios (6); St. Helens (3); Sevenoaks (1); Sheerness (1); Sheffield (29); L.C.C. Shoreditch (12); Slade School (1); Southport (4); Stourbridge (2); Sutton (1); Sunderland (1); Tiverton (5); Toronto (Ontario College) (1); Torquay (5); Wallasey (2); Warrington (9); Watford (25); Westminster (3); Weymouth (4); Weybridge (1); Wigan (4); Wimbledon (8); Wolverhampton (6); Woolwich (6); Wordsley (20); York (1).

NAMES OF JUDGES.

The Judges were appointed by the Council of the Society on the recommendation of the various Sectional Committees. Their names are as follows:—

ARCHITECTURAL DECORATION.

Sir Charles Allom, Chairman of the Section; Arthur J. Davis, F.R.I.B.A.; Geoffrey Fildes, A.R.I.B.A.; Sir Banister Fletcher, F.R.I.B.A.; and Stanley Hamp, F.R.I.B.A.

WALLPAPER.

H. G. Dowling and L. A. Shuffrey.

FURNITURE.

Octavius Satchell, Chairman of the Section; W. Stewart-Greene, Deputy Chairman; W. Nelson Bridges; Ambrose Heal; C. A. Richter; H. D. Searles-Wood, F.R.I.B.A.; and L. A. Shuffrey.

(Sir Banister Fletcher, F.R.I.B.A., and J. Murray Reid were also appointed judges, but were unable to act.)

TEXTILES.

Sir Frank Warner, K.B.E., Chairman of the Section; Colonel W. R. Adam; F. V. Burridge, R.E.; J. H. Dearle; T. C. Dugdale; A. F. Kendrick; Thorold D. Lee; E. W. Tristram; W. Turnbull; A. J. B. Wace; and A. Herbert Woolley.

Book Production.

J. A. Milne, C.B.E., Chairman of the Section; F. V. Burridge, R.E.; N. de Grey; Geo. W. Jones; Major R. Leighton; C. J. L'Estrange; C. H. Prentice; G. H. Palmer; and J. R. Riddell.

(Laurence Binyon, LL.D., and Emery Walker, F.S.A., were also appointed judges, but were unable to act.)

Pottery and Glass.

E. R. Edis, Chairman of the Section; Major Frank Wedgwood, Deputy Chairman; Percy Brooks; M. St. John Hope; H. Irving; J. Leather; Bernard Rackham; and Herbert Webb.

Miscellaneous.

Cadbury Bournville Travelling Scholarship.

J. A. Milne, C.B.E.; Frank Pick; and C. H. Whittaker.

Prize offered by Messrs. Lever Brothers, Ltd.

Charles Berry; J. A. Milne, C.B.E.; and Frank Pick.

Prizes offered by Messrs. Nestlé.

Edgar H. Fisher; J. A. Milne, C.B.E.; and Frank Pick.

Prizes offered by Messrs. J. S. Fry and Sons, Ltd.

Miss B. M. Bradshaw; F. V. Burridge, R.E.; and J. A. Milne, C.B.E.

Prizes offered by Messrs. A. and F. Pears, Ltd.

F. V. Burridge, R.E.; J. A. Milne, C.B.E.; and Robert Pears.

Prize offered by the Proprietors of "The Graphic."

J. A. Milne, C.B.E.; Sir Bertram Mackennal, K.C.V.O., A.R.A.; and Carmichael Thomas.

REPORTS OF JUDGES.

The judges met on various dates between July 9th and 28th, when they examined the work submitted and drew up the various reports printed below.

The number of designs submitted this year (2,033 by 813 candidates) shows a considerable increase on the figure for 1924, when 1,408 designs were entered by 553 competitors. It is interesting to note, as evidence of the growing popularity of the Competition, that among the competitors were some from Durban, Johannesburg, Karachi, Sydney, Toronto and Victoria. On the whole, there was a marked improvement in the quality of the designs, although, as will be seen from the reports of the judges, in some of the sections the work is still very disappointing. Several of the reports draw attention to the lack of originality in the competitors. Originality is a rare and refreshing fruit which cannot be expected to grow on every tree; but, of course, it is a *sine qua non* of the first-class designer, and it is to be hoped that in future competitions it may be more in evidence, though it is, perhaps, but right to throw out a warning that the judges do not at all desire to see it cultivated at the cost of good taste and sanity.

Another *sine qua non* of the good designer is draughtsmanship. Some of the judges comment on the weakness of the competitors in this respect; but, on the other hand, in the sections of Architectural Decoration and Furniture, the level of draughtsmanship is very high.

ARCHITECTURAL DECORATION.

Decorative Architecture.—Designs for a Memorial Library for a College. Eighteen competitors entered for the *en loge* stage of this Competition, and of these eleven completed the finished drawings. In view of the value of the prize—a Travelling Scholarship of £150—the judges are somewhat surprised that the number of entries was not larger.

After the most careful consideration, the Judges awarded the travelling Scholarship to E. D. Wilson (Technical College, Sydney, and Royal Academy Schools). They considered that this competitor has realised the idea of a memorial library for a college more successfully than any other candidate, his designs are restrained and dignified, although the composition of the ceiling is not satisfactory.

The following are commended:—

Miss A. Muriel Hargroves (School of Architecture, University College, London).

J. B. Maxwell (School of Architecture, University of Liverpool).

Wallpaper.—The prize of £10 10*s.* is equally divided between John Henry Garnett (Sheffield Technical School of Art) (No. 1070) and William Charles Reeves (L.C.C. Hammersmith School of Arts and Crafts) (No. 1683).

Commended: Miss Vera Maud Moller (North London Collegiate School of Art) (No. 1768).

TEXTILES.

SUB-SECTION 1. Carpets and Rugs; Moquettes; Floor Coverings; Linoleum and Floor Cloths.

The work submitted attained a good standard of design, some excellent examples being shown under all the headings, Carpets and Rugs, Moquettes, Floor Coverings, Linoleums and Floor Cloths. In the case of carpets, borders should have been submitted as well as the centres, and the designs should be accompanied by a portion drawn to working scale.

The awards are as follows:—

Prize of £10 10*s.* to Frederick Walter Downing Eastaugh (South Mansions, Streatley Road, Kilburn, N.W. 6) (No. 791).

Prize of £5 5*s.* and an Owen Jones Medal to David Edgar Morris (Kidderminster School of Art) (No. 1685).

Prize of £5 5*s.* to Miss Mary Ruth Baynes (L.C.C. Central School of Arts and Crafts) (No. 1022).

Highly commended:

William Reid Robb (92, Harriet Street, Kirkcaldy) (No. 72).

Walter Shepherd (159, Chester Road, Kidderminster) (No. 770).

Miss Muriel Walker (Manchester School of Art) (No. 1976).

SUB-SECTION 2. Tapestries, Damasks, Brocades, Table Damasks, etc.

Whilst the increased number of entries was evidence of the growing popularity of the Competition, by far the most satisfactory feature was the all-round improvement in the standard of design.

The judges were glad to see several designs from Blackburn School of Art, of which No. 1693 was an exceptionally well-drawn and pleasing piece of damask work.

No. 1149, although somewhat vivid in colour, shows life and vigour. It is of a practical nature, well adapted to its purpose, and could be produced to good effect in cloth.

No. 393 shows true tapestry feeling, and some originality in the use of the ornament employed.

No. 104 is well drawn and has excellent damask qualities.

No. 215 is a well-balanced study, and simple in treatment.

Prize of £10 10*s*. and an Owen Jones Medal to Edmund Holden (Blackburn School of Art) (Nos. 1693 and 1694).

Prize of £10 10*s*. to Miss Elsie Thompson (3, Blandford Road, Bedford Park, W. 4) (No. 1149).

Highly commended:
Miss Marjorie Ella Brown (Torquay School of Art) (No. 393).
Miss Violet Lilian Frayer (Regent Street Polytechnic Art School) (No. 827).
Thomas Isherwood (Blackburn School of Art) (No. 1695).
Miss Ena Kingsford (Dunfermline Lauder Technical School) (No. 1).
Francis James Neill (Lismore, Newtownbreda, Belfast) (No. 104).

Commended:
Miss Ethel Heaviside-Williams (Torquay School of Art) (No. 397).
Robert Broadbent Mortimer (Blackburn School of Art (No. 1698).
John Edward Smith (Carlisle School of Art) (No. 215).

Sub-Section 3. Printed Fabrics for Hangings and Furniture, etc.

The designs generally are lacking in freshness; many of them are reminiscent, and inspired by well-known styles. The colour is too often crude, and sometimes vulgar. Many of the works submitted are more suitable, both in colour and design, for wallpapers than for textiles, and indicate insufficient technical knowledge of the printing craft. The realistic treatment of flowers as applied to printed cotton should be more restrained and very carefully considered. The drawing of flowers is in many cases very poor.

On the whole, this Sub-section shows promise rather than attainment, and the judges have made their awards under the influence of that feeling.

Prize of £10 10*s*. to Miss Ethel Mary Bennett (Vorda, Caerleon, near Newport, Mon.) (Nos. 850 to 855). (6 designs.)

This group of designs shows versatility and promise.

Prize of £5 5*s*. to Miss Joan Isobel Booth-Smith (106, Ringstead Road, Catford, S.E. 6) (Nos. 857 to 862). (6 designs.)

This group shows some originality in design.

Highly commended:
Thomas James Corbin (Croydon School of Art) (No. 1106).

Commended:
Miss Molly Booker (Technical School of Art, Godalming) (No. 883).
Thomas Davies (Leeds School of Art) (Nos. 1236 to 1244).
Miss Phillis Joan Moss (Rochdale School of Art) (No. 488).
Frank Nolan (15, Stubbins Lane, Ramsbottom, Manchester) (No. 113).
Miss Alice D. Parkin (Nottingham School of Art) (No. 1626).
Miss Madeline Sagar (Richmond School of Art) (No. 216).
Miss Florence M. Street (Liverpool City School of Art) (No. 362).

SUB-SECTION 4. **Printed Fabrics for Dress, Dress Brocades and Fancy Dress Fabrics; Handkerchiefs; Tie Silks and Mufflers; Ribbons.**

The standard in the printed dress fabrics seemed higher than last year, and more work of promise was to be seen, though taste is in great need of cultivation, and also attention to fashion. Many schools seem to have little or no regard to this, and in designing fabrics for dress, whether printed or woven, fashion is most important, and, of course, must be viewed with good taste. The dress brocades were very unsatisfactory—not at all tasteful, and poor in design and colour.

On the whole there was an improvement in colour, as compared with the work submitted in 1924, but too much insistence cannot be placed on the importance of fresh, bright colour schemes, and an avoidance of dull and dowdy colour generally. Choice of *motif* is also important. Many designs, otherwise good, were really unsuitable owing to the too naturalistic treatment of an unsuitable *motif*. If the *motif* is treated in such a way that it ceases to resemble a naturalistic form, all is well, other things being good; but when it is naturalistically treated, *then* it must be the sort of *motif* one feels suitable to dress.

The handkerchiefs, with the exception of the batiks, were very disappointing. Few schools seem to have the right idea of them. A handkerchief is not a picture and must not be treated as such. Many of this type are seen in the shops, no doubt, but they are to be deplored. Simplicity and good taste are the first considerations, and anything treated in a naturalistic way is obviously out of place.

Some of the batiks depended too much on accidents of the process to be good. The accident should not be cultivated, but should be used intelligently without being forced. Simplicity, again, cannot be too strongly urged. In the design for a batik of any kind the best effects are always obtained by simplicity in design and tasteful choice of dyes.

The tie silks were disappointing, both as to colour and design; and there were few ribbon designs of high merit.

The awards are as follows:—

The Travelling Scholarship of £150, Prize of £10 10*s*., and an Owen Jones Medal to Miss Margery Tomlin (Regent Street Polytechnic School of Art) (Nos. 546 to 556, 558 to 561 and 563).

Prize of £10 10*s*. to Miss Lilian Josephine Pocock (24, Warwick Avenue, W. 9) (No. 100, set of 23 designs).

Prize of £5 5*s*. to Miss Elizabeth Wilson-Haffenden (Croydon School of Art) (No. 1130).

Highly commended:

Miss Gladys Maud Buckridge (Leeds School of Art) (No. 1259).
Miss Ena Louise Coote-Reynolds (Croydon School of Art) (No. 1136).
Miss Ethel Lupton (Manchester Municipal School of Art) (Nos. 1911 to 1921).
Miss Agnes Gwen Thornton (Leeds School of Art) (No. 1249).

Commended:

Miss Eleanor May Marston (9, Wrottesley Road, Willesden, N.W. 10) (Nos. 1199 to 1204).

SUB-SECTION 5. **Lace; Lace Curtains; Embroidery; Open work.**

The general average in this section is higher than in the previous competition. The works submitted show a sharp contrast—a characteristic feature of the work of art students at the present time. On the one hand there are the designs based on traditional motives; on the other, there is the effort to comply with present-day tendencies, and to make full allowance for the limitations imposed by modern machinery, materials and industrial conditions. In addition there are certain works, admittedly showing delicate feeling and a considerable measure of skill which can hardly be included in the category of industrial designs. No disparagement to their merits is implied by their exclusion from the scheme of the awards.

The awards are as follows:—

Prize of £10 10s. and an Owen Jones Medal to Miss Marion Hollis (Dudley School of Art) (No. 509) for "all-round" excellence.

Prizes of £5 5s. each to Mrs. Selina Maiden (Halifax Municipal Technical College) (Nos. 516-519), for variety and skill in execution, and to Miss Ethel Gertrude Thompson (Derby School of Arts and Crafts) (No. 699) for the skilful use of artificial silk.

Highly commended:

Miss Phyllis Croasdale (Blackburn School of Art) (No. 1689). This drawing for embroidery on a black ground shows much skill both in design and in colour-scheme. The judges would have liked to see the work carried out.

Miss Dora Madeleine Power (Derby School of Arts and Crafts) (No. 698). A simple and effective piece of work.

Miss Isabel Mary Smail (Manchester School of Art) (No. 1966). This design is skilfully "finished."

Miss Daisy Rogers Stedman (Nottingham Correspondence College for Applied Designs) (No. 1596). This design is well adapted to modern commercial manufacture; the two-colour (double-dyeing) scheme is well thought out.

Commended:

Miss Sarah Ann Barber (Leeds School of Art) (No. 1229), for careful execution.

Miss Marjorie Christina Butcher (Nottingham College for Applied Designs) (No. 1584), for refinement of design.

Miss Harriet Cooke (Belfast Municipal College of Technology) (No. 1737), as suitable for industrial hand-embroidery.

Miss Florence Cowan (Belfast Municipal College of Technology) (No. 1735), as suitable for industrial hand-embroidery.

Miss Isabel Fergusson (Manchester School of Art) (No. 1879), for effective adaptation of Elizabethan motives.

Miss Dolly Hanna (Belfast Municipal College of Technology) (No. 1740), for suitability for its intended purpose.

Miss June Kirkbride (Lancaster Storey Institute, School of Art) (No. 1468). Although this design is commended, the judges consider that this type of work is not likely to be much in demand in the near future.

Percy Meadwell (Nottingham School of Art) (No. 1624), for skilful adaptation of traditional motives.

Miss Alice Bertha Woodhall (Birmingham School of Arts and Crafts) (No. 480), for suitability for its intended purpose.

In conclusion, the judges draw attention to 1592 and 1597 as showing much originality, though it is doubtful whether they would be successful commercially.

FURNITURE.

The judges have noted with pleasure that as a general rule the designs submitted in this section have been exceedingly well drawn, and the work shows a marked improvement as compared with that submitted last year.

In Sub-Section 3 the subject, "Designs for the complete Furniture of a Study, without reference to traditional style," was prescribed in the hope that some competitors might discover some original power. Unfortunately, this hope has been disapppointed.

The awards are as follows:—

SUB-SECTION 1. Designs for the complete Furniture of a Dining Room decorated in 18th Century Period. Prize of £20 and an Owen Jones medal to Frederick Sidney Maude (Ipswich School of Art) (No. 1536).

SUB-SECTION 2. Designs for the complete Furniture of a Bed Room, decorated in William and Mary Period. Prize of £20 to James Watson (Brixton School of Building) (Nos. 585, 586).

Prize of £10 10s. to Frank William McCall (22, Park Road, Wallasey) (No. 233).

SUB-SECTION 3. Designs for the complete Furniture of a Study, without reference to traditional style. Prize of £10 10s. to Frank William McCall (No. 234).

SUB-SECTION 4. Designs for the complete Furniture of a Working-man's Living Room. Prize of £10 10s. to Ernest Francis Burgess (108, Newbridge Road, Lower Weston, Bath) (No. 846).

Prize of £5 5s. to Donald William Henry Oxlade (Hornsey School of Art) (No. 1679).

SUB-SECTION 5. Design for a Cabinet for Decorative China. Prize of £5 5s. to William Sanders (Barnstaple Science and Art School) (No. 741).

Prize of £3 3s. to William David MacKenzie (Edinburgh College of Art) (No. 327).

SUB-SECTION 6. Designs for Writing Table and Chair. Prize of £5 5s. to Frederick Sidney Maude (Ipswich School of Art) (No. 1534).

No entries were received in Sub-Section 7, "Designs for Garden Furniture in Cane."

BOOK PRODUCTION.

SUB-SECTIONS 1 AND 2. Title pages and three pages of text.—The judges regret that so poor a response has been made by printers to the invitation to take part in the competitions which have for their object improvement in Book Production. With the exception of one or two examples, those sent in are unworthy of the printing craft, and cannot be said to be representative of the work done in average book printing offices.

A number of examples which were submitted for exhibition have been rejected.

The awards are as follows:—

TITLE PAGES. "The History of Tom Jones."

(a) *Set in Type:* Prize of £6 6s. to Harry Felix Paroissier (London School of Printing) (No. 1153).

Prize of £4 4s. to James Shand (53, Anson Road, Tufnell Park) (Nos. 81 and 84).

(b) *Partly decorated.* Prize of £10 10s. to Frederick Angus Horn (Bradford School of Arts and Crafts) (No. 1029).

(c) "*On the Morning of Christ's Nativity.*" Prize of £7 7s. to James Shand (Nos. 85 and 86).
Prize of £3 3s. to Harry Felix Paroissier (No. 1152).

(d) *A Scientific Paper.* Prize of £5 5s. to Harry Felix Paroissier (No. 1154).
Prize of £2 2s. to James Shand (No. 90).

SUB-SECTION 2. The judges are unable to make any award in this Sub-Section, and they regret that no competitor submitted examples of text pages for "The History of Tom Jones" and the Scientific Paper.

SUB-SECTION 3. *Line and Colour Illustrations.*—The standard of designs for both line and colour illustrations is low. Competitors should remember two points: (1) That in illustration imagination plays a more important part than mere technical excellence of execution; and (2) that in line illustration particularly the juxtaposition of type is a governing factor.

It would be pleasant in future years to see more originality in the exhibits.

The awards are as follows:—

FOR A LINE ILLUSTRATION: Prize of £10 10s. to Miss Cecil Higgs (Goldsmiths' College School of Art) (No. 1310).

FOR COLOUR ILLUSTRATIONS: Prizes of £5 5s. each to Alfred Edward Kerr (12, Deramore Avenue, Belfast) (No. 55), and Miss Joan Ivory Packham (Croydon School of Art) (No. 933).

SUB-SECTION 4. *Designs for End-Papers or Cover-Papers.*—The judges found a generally high level in the designs submitted in this Sub-Section. Many of them showed character, combined with appropriateness for their purpose and suitability for production.

As in other classes, some competitors did not observe the condition that the designs were to be suitable for general use. One design (No. 1036), which has been commended, might have received a higher award had this requirement been more carefully considered.

The awards are as follows:—

Prize of £10 10s. and an Owen Jones Medal to Miss Evelyn Dorothy Goggs (L.C.C. Central School of Arts and Crafts) (Nos. 254, 255, 256, 258).
Prize of £10 10s. to Miss Frederica E. Graham (L.C.C. Central School of Arts and Crafts) (Nos. 1320, 1322).
Prize of £5 5s. to Miss Evelyn Gwendoline Maw (L.C.C. Central School of Arts and Crafts) (Nos. 1544-6).

Commended:
Mrs. Saidie Frances Cooper ("Heremai," Kingswood Lane, Hansey Green, Warlingham (Nos. 720, 721).
Frederick Angus Horn (Bradford School of Arts and Crafts) (Nos. 1036, 1039).

SUB-SECTIONS 5 AND 6. *Bindings in Cloth and Leather.*—The judges regret that the designs submitted in these Sections are very weak. None were specially appropriate for the book specified in the conditions, several were even designed for other books. The only design accepted is not considered worthy of any award. The design is not definitely appropriate either to the subject of the book or its period; the lettering on the side is weak, and badly placed, and the design of the back is without sufficient recognition of technique.

Pottery and Glass.

Sub-Section 1. *China.*—The work in this Section shows considerable improvement as compared with that of 1924, though many of the designs indicate lack of appreciation of material, and are impracticable from the manufacturer's point of view.

The judges have much pleasure in awarding a prize of £10 10*s.* and an Owen Jones Bronze Medal to Thomas William Jones (Stourbridge School of Art) (No. 512). His design shows that originality and simplicity of treatment which enable it to be used for the purpose for which it is intended. Its freshness causes the judges to hope that this competitor will be encouraged to persevere in his efforts.

The judges appreciate the two sketches of Norman Thomas Stephen Hull (Derby School of Art) (Nos. 701 and 704), and have much pleasure in recommending No. 701 for a prize of £5 5*s.*, the design being suitable for the purpose intended. In this respect No. 704 fails, for whilst it shows originality and good colouring, it is far too elaborate for the process of lithography.

Miss Vera Huggins (Woolwich Polytechnic) (No. 1062), shows an intelligent appreciation of the terms of the competition, and submits a pleasing design, which is, however, somewhat lacking in originality.

The judges are disappointed that the competitors are not drawn from a wider area, and more especially from districts where the Potting Industry is carried on.

Sub-Section 2. *Earthenware.* On the whole, this Section is disappointing. The drawings submitted show the same faults as in Sub-Section 1, many of the shapes having apparently been designed in entire ignorance of the material to be employed. The competitors have failed to realise the importance of practical shapes, especially in the case of the vegetable dishes. The judges have again to point out that the decorations are over elaborate, the expense of reproducing them being prohibitive. The only design which appeals to the judges and shows promise is No. 312, but in this case no design for a vegetable dish has been submitted.

Sub-Section 3. *Glass: Wine Glass, Tumbler and Decanter.*—The majority of the designs submitted are not up to the judges' expectations, and many of them are quite impracticable from a manufacturer's point of view. The designs of Albert Elcock (Wordsley Art and Technical Institute) (Nos. 649 to 652 inclusive) are commended for lightness of treatment, especially No. 652. The judges are unable to recommend a prize in this section, and suggest that in the future the designs should show greater simplicity.

Sub-Section 4. *Glass: Water Jug, Goblet and Salad Bowl.*—The only design that appeals in any way to the judges is that submitted by Charles Howard Husselbee (Wordsley Art and Technical Institute) (No. 636), which shows original treatment in the shape of the jug.

Sub-Section 5. *Pressed Glass.*—The majority of the designs submitted for pressed glass are quite impossible for the purposes intended and show lack of knowledge of the processes of manufacture. This applies especially to Nos. 1056-1059, which are much too elaborate and practically impossible to produce in pressed glass. No. 639 appears to be a copy of a foreign design. Of the two designs, Nos. 1339 and 1340, the latter would be impossible to reproduce in pressed glass.

MISCELLANEOUS.

POSTERS. Generally speaking, the work in this section was not of a high order. Where originality was shown, most of the designs were either commonplace or strained after effect in wrong directions. The quality of the drawings, with few exceptions, left a great deal to be desired. Designs, relying, as they should do, on smart and original ideas, well drawn and carried out with taste and simplicity, were few and far between.

In the Section for a design for a "Gift Box" for Messrs. A. and F. Pears, the character of the designs did not justify awards being granted.

In the Section for designs for Posters for "Ideal Milk," the Judges very much regret that they did not find any which justified the granting of the awards. Messrs. Nestlés, who had kindly offered the prizes, were anxious that they should be apportioned, but notwithstanding this, the Judges decided that it would not be right to make awards unless they were of a sufficiently high standard.

The winning designs in the "Nestlé's Milk" Section stood out as possessing some real merit. The one to which the first prize was awarded was well and originally treated in colour and design, and fulfilled the requirements of a refined and telling Poster. The winning designs in the other Sections also showed considerable promise, and deserve high praise.

It was pleasing to note that some of the younger competitors produced the best work, and this should be encouraging to others.

On the whole, the general tendency was towards improvement, as compared with last year's Competition, but it is obvious that Competitors should devote their attention to the study of drawing, and endeavour to obtain the right atmosphere in the carrying out of their designs. They should carefully consider, first of all, whether their idea or slogan is likely to sell the article advertised, and, secondly, if the illustration is sufficiently bold in form and colour to command attention.

The judges desire to draw special attention to the success of the Nottingham School of Art, the students of which won four of the five prizes awarded for posters, as well as the prize offered by the proprietors of the *Graphic*. In addition to this, four of their designs were "Highly Commended," and two "Commended."

POSTERS FOR THE TRAVELLING SCHOLARSHIP OFFERED BY MESSRS. CADBURY BROTHERS, LTD.

The Cadbury Bournville Travelling Scholarship of £50 is awarded to:
Miss Ivy Evelyn Norman (Nottingham School of Art) (No. 1643).

Highly commended:
Edward Loxton Knight (Nottingham School of Art) (No. 1639).
Gerald Leake Searson (Nottingham School of Art) (No. 1649).

Commended:
Wilfred Charles Balloch (Nottingham School of Art) (No. 398).
Miss Aline Dugard (Nottingham School of Art) (No. 1632).

POSTERS FOR PRIZE OFFERED BY MESSRS. LEVER BROTHERS, LTD

The prize of £50 is awarded to:
Alfred Kemp Wiffen (Nottingham School of Art) (No. 1657).

Highly commended:
Albert Edward Halliwell (Southport Victoria School of Art) (No. 1759).
Edward Loxton Knight (Nottingham School of Art) (No. 1642).

Commended:

Miss Kathleen Ardern (Sheffield Technical School of Art) (No. 1064).

Miss Gwynedd Mary Hudson (The Wick Studio, Hove, Sussex) (No. 626).

Posters for Prizes Offered by Messrs. Nestlé.

Nestlé Milk Poster.

The First Prize of £50 is awarded to:

Miss Aline Dugard (Nottingham School of Art) (No. 1633).

The Second Prize of £25 is awarded to:

Clifford Lee (Sheffield Technical School of Art) (No. 1075).

The Third Prize of £10 is divided between:

Joseph Whitehead (Hyde School of Art) (No. 667); and

Alfred Kemp Wiffen (Nottingham School of Art) (No. 1658).

Highly commended:

Miss Ivy Evelyn Norman (Nottingham School of Art) (No. 1645).

Commended:

Leo Hardy (Sheffield Technical School of Art) (No. 1072).

Miss Wilma Hickson (142, Gower Street, W.C.) (No. 1312).

Ideal Milk Poster.

Commended: Wilfred Charles Balloch (Nottingham School of Art) (No. 1628).

Prizes Offered by Messrs. J. S. Fry and Sons.

Display Box Lid and Label.

The First Prize of £25 is divided between:

Joseph Bentham Jenkinson (Liverpool City School of Art) (No. 341); and

Miss Bertha Julia Olyett (The Black and White Studios, 12-13, Bedford Street, Strand, W.C.) (No. 1194).

A prize of £5 each is awarded to:

Miss Marjorie Willmott Robinson (Sheffield School of Art) (No. 1086); and

Miss Verna Camidge Stead (Keighley School of Art) (No. 616).

"Somerdale" Wrapper.

The First Prize of £25 is divided equally between:

John Francis Smith (2, Alder Grove, Waterloo, Liverpool) (No. 471); and

Miss Maeve Wolfe (The Poult House, Pitts Wood, Tonbridge, Kent) (No. 1432).

A prize of £5 each is awarded to

Miss Mary Dawson (Keighley School of Art) (No. 613); and

Miss Enid Gwynedd Stokoe (Croydon School of Art) (No. 1123).

Prize Offered by the Proprietors of the "Graphic."

Although some of the designs showed considerable merit, the judges could have wished for more signs of originality, and they consider that in many cases the drawing was very weak. Three of the works submitted showed outstanding merit, and in the opinion of the judges the design selected for the prize fulfilled the conditions required by the donors.

A Prize of £25 and an Owen Jones Medal is awarded to Alfred Kemp Wiffen (Nottingham School of Art) (No. 1659).

Highly commended:

Miss Mary Steveni Lea (Southport Victoria School of Art) (No. 1757), and

Ronald Alfred Harrison (Bath Municipal Technical College (Art School)) (No. 426).

VISIT OF H.M. THE QUEEN.

The Council have the honour to report that, as in 1924, Her Majesty the Queen visited the Society's Exhibition of Industrial Designs at the Victoria and Albert Museum, and was graciously pleased to purchase a design for a tapestry panel.

APPENDIX.

List of Subscribers to the Prize and Scholarship Fund.

	£	s.	d.
Messrs. Tootal Broadhurst Lee Co., Ltd.	100	0	0
The Federation of Calico Printers	50	0	0
Messrs. Lever Bros., Ltd.	50	0	0
Messrs. Simpson and Godlee, Ltd.	50	0	0
Messrs. Waring and Gillow, Ltd.	50	0	0
The British Flint Glass Manufacturers' Association	30	0	0
Messrs. Turnbull and Stockdale, Ltd.	25	0	0
Harold Waring, Esq., C.B.E.	25	0	0
Messrs. G. P. and J. Baker, Ltd.	20	0	0
Through John Emsley, Esq., J.P.			
Messrs. J. Emsley and Co., Ltd.	20	0	0
Messrs. Peel Bros. and Co., Ltd.	20	0	0
Messrs. John Priestman and Co., Ltd.	20	0	0
Messrs. John H. Smith and Co., Ltd.	20	0	0
Messrs. John Speight, Son and Co., Ltd.	20	0	0
Lord Riddell	20	0	0
Royal Institute of British Architects	20	0	0
Sir Frank Warner, K.B.E.	20	0	0
Bookbinding Section, London Chamber of Commerce	15	15	0
Messrs. Brintons, Ltd.	10	10	0
Messrs. John Brown and Son, Ltd.	10	10	0
Syndics of the Cambridge University Press	10	10	0
The Carpet Manufacturing Co., Ltd.	10	10	0
Carpet Trades, Ltd.	10	10	0
Delegates of the Clarendon Press	10	10	0
Messrs. John Crossley and Sons, Ltd.	10	10	0
Messrs. John Dickinson and Co., Ltd.	10	10	0
The Haberdashers' Company	10	10	0
Messrs. Hampton and Sons, Ltd.	10	10	0
Messrs. William Heinemann, Ltd.	10	10	0
Joiners' Company	10	10	0
Messrs. John Line and Sons, Ltd.	10	10	0

	£	s.	d.
John Murray, Esq., C.V.O.	10	10	0
Messrs. William O'Hanlon and Co., Ltd.	10	10	0
Messrs. Fred Parker and Sons, Ltd.	10	10	0
Messrs. H. and M. Southwell, Ltd.	10	10	0
Messrs. Tomkinson and Adam	10	10	0
The Weavers' Company	10	10	0
Messrs. Chatto and Windus	10	0	0
E. Kahn, Esq.	10	0	0
Messrs. Longmans, Green and Co.	10	0	0
Messrs. Riddick, Stuttart, Ltd.	10	0	0
Messrs. W. H. Smith and Son	10	0	0
Messrs. Henry Stone and Son, Ltd.	10	0	0
Messrs. White, Allom and Co.	10	0	0
Messrs. Story and Co., Ltd.	6	6	0
George Barber, Esq.	5	5	0
Messrs. Bourne and Hollingsworth, Ltd.	5	5	0
Messrs. Gabe and Pass, Ltd.	5	5	0
John Gibson, Esq.	5	5	0
Mrs. E. Graydon-Bradley	5	5	0
Messrs. Heal and Son, Ltd.	5	5	0
William Jardine, Esq.	5	5	0
Messrs. Keeble (1914), Ltd.	5	5	0
London Cabinet and Upholstery Trades' Federation	5	5	0
Messrs. Mander Bros., Ltd.	5	5	0
The Medici Society, Ltd.	5	5	0
Thomas Muddiman, Esq.	5	5	0
Messrs. Neckwear, Ltd.	5	5	0
Federation of Lace and Embroidery Employers' Association	5	5	0
Federation of Master Printers and Allied Trades	5	5	0
Messrs. Shuffrey and Co.	5	5	0
Messrs. Stead, McAlpin and Co.	5	5	0
Messrs. William Thompson and Co., Ltd.	5	5	0
Paul Waterhouse, Esq., F.S.A., F.R.I.B.A.	5	5	0
Messrs. Josiah Wedgwood and Sons, Ltd.	5	5	0
Anonymous	5	0	0
Society of Architects	5	0	0
Messrs. Blackwood, Morton and Sons, Ltd.	5	0	0
Messrs. Crofts and Assinder, Ltd.	5	0	0
Edgar Greenwood, Esq.	5	0	0
Messrs. George G. Harrap and Co., Ltd.	5	0	0
Messrs. A. W. Hewetson, Ltd.	5	0	0

	£	s.	d.
Sir Ernest Hodder-Williams, C.V.O.	5	0	0
Messrs. A. B. Jones and Sons	5	0	0
Messrs. Arthur H. Lee and Sons, Ltd.	5	0	0
Messrs. R. H. and S. L. Plant, Ltd.	5	0	0
Percy Scott Worthington, Esq., M.A., F.R.I.B.A. ..	5	0	0
Stationers' Company	4	4	0
Messrs. Bath Artcraft, Ltd.	3	3	0
Bath Cabinet Makers' Co., Ltd.	3	3	0
Messrs. Collins and Hayes	3	3	0
Empire Bedsteads, Ltd.	3	3	0
C. Erard, Esq.	3	3	0
Messrs. H. Herrmann, Ltd.	3	3	0
Messrs. J. Aynsley and Sons	2	2	0
Messrs. J. and W. Bastard	2	2	0
Messrs. Beresford and Hicks	2	2	0
S. D. Bianco, Esq.	2	2	0
Messrs. William Birch, Ltd.	2	2	0
Messrs. A. Cooper and Co...	2	2	0
The Coventry and District Textile Manufacturers' Association	2	2	0
Messrs. Crotty and Polsue	2	2	0
R. D. Earle, Esq.	2	2	0
Messrs. H. S. Fraser, Ltd.	2	2	0
A. C. Gill, Esq.	2	2	0
Messrs. Joseph Johnstone, Ltd.	2	2	0
Messrs. W. Skull and Son, Ltd.	2	2	0
Messrs. H. Wilson and Sons	2	2	0
Messrs. G. H. and S. Keen	2	0	0
E. R. Edis, Esq.	1	6	6
F. W. Atkinson, Esq.	1	1	0
A. Barone, Esq.	1	1	0
C. H. Bowers, Esq.	1	1	0
Messrs. J. C. H. Brouwers and Son	1	1	0
H. Bucknell, Esq.	1	1	0
Cedric Chivers, Esq.	1	1	0
The City Cabinet Company	1	1	0
H. J. Colclough, Esq.	1	1	0
Messrs. Dancer and Hearne Bros.	1	1	0
Messrs. S. Epstein, Ltd.	1	1	0
Godfrey Giles, Esq...	1	1	0
Arthur Keen, Esq., F.R.I.B.A.	1	1	0
S. D. Kitson, Esq., F.R.I.B.A.	1	1	0

	£	s.	d.
Messrs. J. Osborne and Co.	1	1	0
Professor Beresford Pite, F.R.I.B.A.	1	1	0
Messrs. W. W. Ratcliff and Co., Ltd.	1	1	0
C. A. Richter, Esq.	1	1	0
Sir G. Gilbert Scott, R.A.	1	1	0
Messrs. I. Sklanowitz	1	1	0
B. R. Field, Esq.	1	0	0
The "X" Chair Patents Co., Ltd.	1	0	0
E. Gomme, Esq.		10	6
H. R. Linton, Esq.		10	6
Messrs. Lotinga Bros.		10	6
Messrs. D. Burkle and Son		10	0
C. Van Doorsselaer, Esq.		5	0
Total	£1096	13	0

NEW TAPESTRIES IN THE VICTORIA AND ALBERT MUSEUM.

The Trustees of the Bowes Museum at Barnard Castle have lent to the Victoria and Albert Museum, South Kensington, several interesting tapestries. The largest is a fragment of the Triumph of Time, a Flemish tapestry of the early 16th century one of the famous series inspired by Petrarch's allegorical poem *I Trionfi*, representing the Triumphs of Life, Chastity, Death, Fame, Time and Divinity. The Museum possesses three Triumphs—Chastity, Death and Fame—and at Hampton Court there are the Triumphs of Death, Fame, and Time from another set. The Bowes Museum fragment belongs to a series woven for Philip of Cleves (b. 1456, d. 1528) Lord of Ravensteyn and Wijnondael, and bears his arms. It differs from the Museum and Hampton Court sets in that it lacks the elaborate border with inscriptions.

The second panel is Brussels work of the later 17th century, and bears the initials of the weaver I.D.M., probably the signature of Jan de Melter (d. 1698), who was one of the leading weavers at Brussels, and left that city about 1688 to set up looms at Lille. The subject, the Crucifixion, is copied from a picture by Vandyck in the Vienna Museum.

The third piece, Roman work of the early 18th century, is a portrait of a Pope, probably Clement XI., who established the tapestry looms in the Ospizio di San Michele in 1710.

GENERAL NOTE.

Discovery of Coal at Mysore.—As a result of mining operations conducted for several months in the Indian state of Mysore, writes the United States Consul at Madras, coal has been discovered at Kamasamudram, which is 18 miles by rail from the railway station known as Bowringpet. The Government of the Mysore State wishes to sink a small prospecting shaft and has commissioned a gold mining company to undertake this work. A new coal mine in South India, if operated successfully, will be a great economic asset in the matter of conducting the various Mysore gold mines and in supplying the South Indian railways. Local industries, railways, and steamers are now largely dependent upon coal which is imported from Bengal, and from the Native State of Hyderabad.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

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FRIDAY, AUGUST 21, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

MONDAY, JULY 27TH, 1925.

SIR RICHARD REDMAYNE, K.C.B., M.Sc., M.Inst.C.E., M.I.M.E., M.I.M.M., F.G.S., late Chairman-Governor, Imperial Resources Bureau, in the Chair.

THE CHAIRMAN, in introducing the reader of the paper (Professor W. A. Parks), paid a tribute to the interest which the Royal Society of Arts took in all matters which had for their object the development of the economic resources of the Empire. Professor Parks was a very well-known geologist, who for thirty years had been connected with the University of Toronto, and who was now head of the geological department of that important University, as well as President of the Royal Society of Canada, and President-Elect of the Geological Section of the British Association. There was nobody more competent to speak on the very important subject of the mineral resources of Ontario, a part of the Empire which at the present time was occupying the attention of all the leading mining and metallurgical experts of the Empire, of which it was one of the most highly mineralised portions.

The paper read was:—

THE MINERAL RESOURCES OF NORTHERN ONTARIO.

By W. A. PARKS, Ph.D., F.R.S.C., F.G.S.A. Professor of Geology, University of Toronto.

The Dominion of Canada extends in longitude about 3,500 miles and in latitude more than 1,400 miles. The estimated area is 3,603,910 square miles.

The structural basement of this great area is the continental mass of pre-Cambrian rocks. On this basement later marine strata have been deposited by successive invasions of the seas throughout the geological ages. Small areas of the ancient complex, in the Cordilleran and Appalachian regions, are still uncovered by later strata, but the greatest area of exposed pre-Cambrian rocks lies in the form of a great V around Hudson Bay. This region has been variously named, the Archæan V, the pre-Cambrian axis, the Laurentian peneplain, the Continental protaxis, and the Canadian Shield. The area of the Shield in Canada is about 1,900,000 square miles or more than half the extent of the whole Dominion.

Before considering the mineral resources of this great area it is advisable to present in outline the general geology of the Canadian Shield and, also, to draw attention to certain superficial conditions that seriously affect the discovery and winning of ores.

Since the days of the pioneer Canadian geologist, Sir William Logan, the classification of the complicated pre-Cambrian formations has engaged the attention of Canadian geologists, and not yet has unanimity of opinion been attained.

It is now generally admitted that two major periods of immense duration can be recognised. The earlier of these, sometimes called the pre-Huronian, was a time of tremendous volcanic activity, at least in the southern part of the Shield, resulting in the formation of tens of thousands of feet of lavas and other igneous rocks (Keewatin) associated with clastic sediments—conglomerates, greywackés, etc., These sedimentary masses are sometimes of considerable area with lengths up to 100 miles and thicknesses of several thousand feet. Their relationships with the volcanic Keewatin are difficult to ascertain: in some cases they seem to alternate with Keewatin rocks, in others they are more distinctly later. Various names have been given to these sedimentary formations, chiefly on account of geographical isolation, *e.g.*, Doré, Misi, Sudbury, Timiskaming, Coutchiching.

During pre-Huronian time mountain-building forces were at work, great ranges were formed, and enormous batholiths of granite-gneiss were intruded into the Keewatin volcanics and associated sedimentaries. It is fairly well established that at least two distinct periods of mountain-building and batholithic intrusion disturbed the continuity of conditions in pre-Huronian time. The earlier granites and gneisses are usually called Laurentian, and the later Algoman. At one time Canadian geologists were rather dogmatic regarding two distinct periods of granitic intrusion. At present it is recognised that only in exceptional cases can these granites be differentiated in the field and that periods of intrusion other than Laurentian and Algoman may have occurred. It would appear, also, that in the differentiation of the granites there is a question of extreme importance to the gold-mining industry, as it is known that Algoman granite is responsible for the great gold deposits whereas gold is not known to have accompanied the Laurentian batholiths. Perhaps the method of determining the age of rocks by means of the radio-active minerals will eventually enable us to differentiate the pre-Huronian batholiths with certainty.

These earlier pre-Cambrian (pre-Huronian) rocks contain nearly all the gold, most of the iron, and some of the copper of the Canadian Shield.

Following the last batholithic intrusion of granite-gneiss came a long-con tinued and profound erosion whereby the great batholiths were exposed and worn down to their cores, leaving the Keewatin and associated rocks as mere remnants in the immense areas of granite-gneiss.

Following this long period of erosion came the later pre-Cambrian or Huronian a time of sedimentation and of volcanic activity, particularly towards its close. Great diversity of opinion exists as to the nomenclature of the formations. Avoiding a discussion of this matter I shall content myself with introducing the classification approved by Dr. W. H. Collins, Director of the Geological Survey of Canada.

TABLE I.

SUBDIVISIONS OF THE UPPER PRE-CAMBRIAN.

CANADA.	UNITED STATES.
Huronian.	Algonkian.
Keweenawan ; erosion remnants of conglomerate, sandstone, and volcanic flows ; sills and dykes of diabase and norite ; batholithic intrusions of granite (Killarney).	Keweenawan ; a series of conglomerate, sandstone and volcanic flows 48,000 feet thick ; dykes and sills of diabase ; batholithic intrusion of granite (Presquisle, etc.)
Animikie (Whitewater) ; a series of conglomerate, volcanic tuff, carbonaceous slate, and sandstone, 7,500 feet thick.	Upper Huronian ; a series of conglomerate, slate, quartzite, and iron-formation, 2,000-12,000 feet thick, with associated basic lavas.
Cobalt ; a series consisting basally of boulder conglomerate and other materials, probably of glacial origin, overlain by quartzite and calcareous quartzite, about 12,000 feet thick.	Middle Huronian ; a series of conglomerate, quartzite, slate and iron-formation, about 3,000 feet thick, with which are associated basic lavas.
Bruce ; a series of conglomerates, quartzites and impure dolomitic limestone, 2,700-12,000 feet thick, resting in profound unconformity upon an older basement called the pre-Huronian.	Lower Huronian ; a series of conglomerate, impure dolomitic limestone, quartzite, and slate, about 2,500 feet thick, resting in profound unconformity upon an older basement called the Archæan.

It will be noted that the three lower divisions consist essentially of sediments but that the upper or Keweenawan is characterised by " sills and dykes of diabase and norite." We have learned to regard these eruptives as the source of the native copper of Michigan and the north shore of Lake Superior, of the nickel and copper ores of Sudbury, and of the silver and cobalt ores of the Cobalt district.

These Huronian rocks are disposed in relatively small areas over the Canadian Shield. Together with the early pre-Cambrian they form probably rather more than twelve per cent. of the total area of the Shield*, *i.e.*, they cover about

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*I must disclaim responsibility for this statement ; it is a rough estimate which I cannot at present verify.

230,000 to 250,000 square miles. This extent will doubtless be increased by the discovery of new patches in the little-explored regions of the far north. All the rest of the immense area of the Canadian Shield, as far as is known, is composed of granite-gneiss which, hitherto, has yielded no valuable metallic ores although it is believed that the Algoman granite is the source of the gold, but only in apophyses cutting the older rocks.

We are justified in regarding most of this 250,000 square miles as legitimate ground for the activities of the prospector. It is necessary, however, to point out that this area is somewhat reduced by the wonderful profusion of lakes and of the characteristic Canadian " muskegs". The glaciers of the Ice Age passed over a region already profoundly eroded, reduced the hills still further, and blocked the old lines of drainage with débris. On the advent of present climatic conditions there were no established drainage systems, the water filled the depressions and spilled over in successive cascades to lower and lower levels Thus arose the innumerable lakes and the rivers with their calm stretches and sharp waterfalls.

This extraordinary system of waterways makes it possible to reach any point in the Shield. I will engage to go alone with the aid of a two-fathom canoe to any designated point in Northern Ontario. The blocked drainage, together with a generous rainfall, has stimulated the growth of vegetation over the whole of the Ontario part of the Shield. This circumstance adds greatly to the difficulty of prospecting and materially reduces the area immediately available.

Differential erosion is a factor not to be disregarded in estimating the possible mineral resources of this region. Pre-glacial, glacial, and post-glacial erosion have combined to attack the softer rocks and the weakened lines of contact in which the metallic ores are chiefly contained, leaving the harder, unproductive elements of the complex to constitute the accessible hills. I am averse to unjustifiable optimism and visionary conclusions but I am assured that we have in this factor of differential erosion a real element to modify our views, and I believe that the intensive prospecting of the future will reveal under the muskegs and lakes and in the clay-filled valleys a mineral wealth far in excess of that disclosed by the bare and rocky hills.

In these preliminary remarks it has been necessary to speak of the Shield as a whole, for Ontario is only a political division defined both to the east and to the west by imaginary lines not determined by geological or topographical features.

Northern Ontario is commonly regarded as the region north of Lake Nipissing, the French river and the upper Great Lakes. All this area is composed of pre-Cambrian rocks with the exception of about 100,000 square miles in the Palæozoic coastal plain south-west of James Bay.

Whether as a matter of fact or because the region is better known the area of rock other than granite and gneiss is more than our rough estimate of twelve per cent. for the whole Shield; it is possibly as great as twenty or even twenty-five per cent. but I have no means of giving a definite figure with assurance.

It is probable that the total area of Northern Ontario's pre-Cambrian rocks is about 260,000 square miles; allowing twenty per cent. for the area of productive rocks we have a legitimate prospecting ground of 52,000 square miles, subject to the limitations already stated.

The metals derived from these areas, arranged in order of value of total production to the end of 1924 are as follows:—*

Silver	$234,418,000
Nickel	$197,600,000
Gold	$154,419,000
Iron	$ 85,293,000
Copper	$ 68,108,000
Cobalt	$ 13,725,000
Other metals (platinum metals, lead, zinc, etc.)	$ 17,725,000
	$771,485,000

I now propose to review in the briefest possible manner the above metals in the order shown in the table and to supplement that review by a short reference to the non-metals and to general conditions.

SILVER.

Silver mining in Ontario dates back to 1868 when a vein carrying native silver was discovered on a tiny island off the shore of Thunder Cape, Lake Superior. From the mine eventually opened (Silver Islet Mine) about 3,000,000 ounces of silver were recovered.

Naturally, the surrounding territory was prospected and numerous veins were found. None of these proved as rich as the Silver Islet vein, but between the years 1868 and 1885 they added an output of 1,000,000 fine ounces making the total production from the area 4,000,000 ounces of silver.

The native silver in this area occurs in veins cutting Animikie rocks and, undoubtedly, it was derived from the Keweenawan eruptives. The veins carry a little cobalt and nickel thus showing a resemblance to those of the great Cobalt field farther east, and suggesting a comparison as to genesis with the deposits of the Sudbury nickel area.

All the mines in the Thunder Bay district have long since been abandoned; despite recent attempts to rework some of them there has been no recorded production. It is generally felt, however, that the possibilities of the district are by no means exhausted.

It is to north-eastern Ontario, however, that one must look for the development of a great silver mining industry in the province. Here lies the famous

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*These figures refer to the whole of Ontario.

Cobalt area and the lesser but still important areas of South Lorraine, Gowganda and Elk Lake.

In this region basic igneous rocks of Keweenawan age have penetrated the older schists and sedimentaries, particularly those known as the Cobalt series consisting of conglomerates, grits, greywackés, etc. In the fractures in the surrounding rocks, and to some extent in the eruptives themselves, veins have been formed by emanations from the cooling igneous matter. These veins, chiefly with a calcite gangue, contain native silver and smaltite in particular; but many silver, cobalt, and nickel compounds with sulphur and arsenic occur as well.

The original discovery was made in 1903 during the construction of the Timiskaming and Northern Ontario railway. In 1904 prospectors began to flock to the field but many of them left in disappointment long before the greater discoveries were made. The veins, while extraordinarily rich, are of necessity small and not easily found in a region well covered with vegetation and with a considerable mantle of soil. The eventual development was spectacular and the recovery of silver so great that the Cobalt area became the leading silver producing district of the world. Ores running as high as 12,000 ounces to the ton were rapidly mined and the peak of production was attained in 1911 with an output of 31,507,791 fine ounces valued at $15,953,847. In 1912 the output was slightly less in quantity but greater in value owing to an increase in the market price of silver—$17,408,935.

Since the time of maximum output there has been a falling-off in production and leaner ores are being worked but the camp is far from exhausted as the figures in Table II indicate.

The total production from the Cobalt camp to the end of 1924, in round numbers, is 350,000,000 fine ounces of silver and there has been paid to shareholders in dividends and bonuses $91,288,081.

The falling-off of production at Cobalt has been compensated in part by the increased output from South Lorraine. The workings in the township of Casey have been closed and the production from Gowganda is declining. One would be foolishly optimistic not to recognise the fact that the production from the veins at present known is declining, but he would be equally pessimistic to conclude that no further veins will be found in the camp or that no other area of cobalt-silver veins will be found. The revival in South Lorraine and the discovery of very rich veins in a region thought to have been exhausted is in evidence. I am glad to be able to state that still further rich veins have been located in South Lorraine, since the last official reports were published, also, that in Cobalt proper new veins have been discovered within the last few months. There is an assured output from the Cobalt field for many years to come.

With regard to the possibility of development in other areas, I need only state that similar eruptives with the characteristic streaks and stains of cobalt bloom are known in other districts. There is no apparent geological reason why these similar rocks, occurring under similar conditions, should not carry silver. The discovery of another Cobalt would be no surprise to me, should such discovery be made I hope that the British investor will not allow all the prizes to go to New York.

TABLE II.

SHIPMENTS OF SILVER FROM THE COBALT CAMP.

Year	Average price, cents per ounce (New York)	Silver Shipments in Troy Ounces 1904-1924.					
		Total Ounces	Cobalt	Casey Township	South Lorrain	Gowganda	Montreal River and Maple Mountain
1904	57.221	206,875	206,875	—	—	—	—
1905	60.352	2,451,356	2,451,356	—	—	—	—
1906	66.791	5,401,766	5,401,766	—	—	—	—
1907	65.237	10,023,311	10,023,311	—	—	—	—
1908	52.864	19,437,875	19,424,251	500	13,124	—	—
1909	51.502	25,897,825	25,658,683	26,185	194,955	—	18,002
1910	53.486	30,645,181	29,849,981	92,544	221,133	471,688	9,835
1911	53.340	31,507,791	29,989,893	114,789	933,912	468,687	510
1912	60.835	30,243,859	28,605,940	253,824	834,119	549,976	—
1913	57.791	29,681,975	28,105,505	825,108	248,992	502,370	—
1914	54.811	25,162,841	24,155,699	499,643	108,199	399,300	—
1915	49.684	24,746,534	24,280,366	223,939	—	242,229	—
1916	65.661	19,915,090	19,008,517	445,900	77,280	383,393	—
1917	81.417	19,401,893	18,327,258	—	10,000	1,064,635	—
1918	96.772	17,661,694	16,807,407	143,901	72,188	638,198	—
1919	111.122	11,214,317	10,314,689	171,278	4,586	723,764	—
1920	100.900	10,845,436	10,402,249	—	8,253	433,352	1,582
1921	62.654	8,261,931	7,673,535	1,101	328,886	258,292	117
1922	67.521	10,695,133	9,235,147	1,028	1,284,307	170,651	—
1923	64.873	10,493,097	7,375,469	—	2,955,646	160,761	1,221
	Total	343,895,780	327,175,998	2,943,641	7,295,580	6,467,296	13,265
1924*	66.781	9,623,576	6,392,460	—	2,633,058	598,058	—

*Preliminary figures.

NICKEL.

(With copper in part).

In the region north of Sudbury a great sill of Keweenawan eruptive was forced in between Animikie sediments and the older rocks. This sill has assumed a boat-shaped form with a length of about 40 miles and a width of somewhat more than 15 miles. In cooling, the molten mass first gave rise to the ores—chalcopyrite and nickeliferous pyrrhotite—which settled to the bottom. Further cooling resulted in the making of a rock of basic composition —norite; finally the more acid residuum consolidated as micro-pegmatite. Owing to the curvature of the sill into a boat-shaped form, the *bottom* is evidently the *outside* on the horizontal plane of the earth's surface.

Valuable deposits of nickel-copper ores, some of them of tremendous size, have been found at various points along this outer margin of the eruptive. Theoretically there should be a continuous band of ore, but Nature has not been so prodigal or we have not been able to establish the actual continuity. On the other hand, so great a number of occurrences have been found, all along the lines indicated, that we are justified in placing reliance in the theory, and we may reasonably hope for many future discoveries by diamond drilling or other means of intensive prospecting in the regions where the contact of the eruptive with the adjacent rocks is now masked or otherwise made inaccessible.

The first discovery in the Sudbury district was made in 1883 at the point where the main line of the Canadian Pacific railway crosses the basic edge of the eruptive. The deposit there located was exploited by H. H. Vivian and Company as the Murray mine. It is much to be regretted that this deposit is of low grade compared with many others in the Sudbury field, a circumstance which compelled the cessation of operations in 1894 that had a very bad effect on the industry at that time. To-day the lower grade ores can be treated profitably; they are even in demand for making mixtures for metallurgical purposes; in consequence, the Murray deposit has been investigated by diamond drilling and the presence of 4,000,000 tons of ore revealed.

The Canadian Copper Company was a pioneer in the district operating at first the Copper Cliff, Evans, and Stobie mines. About in 1900 work began on the great Creighton mine which has dominated the situation from that time to the present. In 1902, the Canadian Copper Company became part of the International Nickel Company an organisation embracing many interests and now one of the two great producers of the district.

The Mond Nickel Company was formed in 1900 and has just celebrated its 25th birthday by a dinner in London at which I had the honour to be present. The early vicissitudes and eventual triumph of this company is an industrial romance ably outlined by Sir Alfred Mond on that occasion.

Besides the two great corporations mentioned above, smaller companies have operated with varying success. The chief of these was the British America Nickel Corporation which went into liquidation in July, 1924. This failure was in no way due to any fault in the mine or in the smelting plant; it is attributed to the action of the two greater companies in reducing the price of nickel in order to stimulate its further use in the arts.

The production from the Sudbury district for the past four years and for the two previous intervals of five years is shown in table III.

The total production of nickel from 1889 to the end of 1924 was 508,734 short tons, and of copper (1886-1924) 278,380 short tons. The district now produces 90 per cent. of the world's nickel. Immense reserves of ore are positively known by diamond drilling. the Creighton mine alone, above the 2,000 foot level has a proved reserve of 10,000,000 tons, and Dr. C. V. Corless has stated before this Society that the presence of no less than 100,000,000 tons

TABLE III.

NICKEL-COPPER MINING AND SMELTING.

Schedule.	1913	1918	1921	1922	1923	1924
Ore raised ....tons	784,697	1,643,949	262,593	259,569	1,187,354	1,411,980
Ore smelted......... „	823,403	1,559,892	393,768	314,120	1,140,160	1,308,694
Bessemer matte produced ...... „	47,150	87,184	19,498	17,324	58,084	65,943
Nickel content of matte ...... „	24,838	45,886	9,128	8,678	31,029	34,638
Copper content of matte ...... „	12,938	23,843	6,323	5,422	15,769	18,490
Matte exported ... „	—	—	10,466	19,831	21,450	26,565
*Matte refined in Canada ... „	—	5,334	5,558	10,340	31,765	37,613

*Refining in Canada began at Port Colborne, Ontario, in 1918, and at Deschênes, Quebec, in 1920.

has been definitely revealed by diamond drilling throughout the district.

The nickel industry is now far past the speculative stage and has become a settled business. With more and more uses for nickel being found, a still greater demand for the metal is to be anticipated—a demand which the Sudbury nickel field can undoubtedly meet.

I recall the early days of Sudbury and the difficulties of that time. I first went to Sudbury in 1892 as chemist to the old Chicago mine and for a short time afterwards served the Canadian Copper Company in a similar capacity. The use of nickel in steel but recently had been discovered and this use constituted practically the only application of the metal. The production bid fair to swamp the market and little or no money was available for development. Prospectors and small owners flocked to New York for capital and frequently returned empty handed. The closing of the Murray mine in 1894 was a severe blow to the district, but the entry of the Mond Nickel Company in 1900 and the consolidation of interests in the International Nickel Company in 1902 placed the industry on a firm financial basis. The problem to-day is not so much the location of further ore bodies as the creation of a market for the immense quantities of metal that the deposits now known are capable of producing.

Great advances have been made in the treatment of the ores. Hand sorting and roasting in heaps is being replaced by magnetic sorting, flotation of low grade, and roasting in Dwight Lloyd furnaces. The Mond Company has now four of these furnaces each capable of handling 100 tons a day; it has solved the problem of magnetic sorting, and proposes to instal an acid-recovery plant at Coniston. The International Nickel Company has made an exhaustive examination of the old Frood mine and is erecting a pilot mill in order to work out a suitable system for the treatment of the immense quantity of low grade ore.

GOLD.

Gold was first discovered in Ontario at the Richardson location north of Belleville in 1866; in Northern Ontario it was first found in 1871 at the Huronian mine. Then followed discoveries in the Lake-of-the-Woods region, at various points north of Lake Superior, and generally throughout the Keewatin areas of the western part of Northern Ontario. Boom followed boom and poor judgment seconded by extravagance resulted in the closing of all the western gold mines after a considerable production had been recorded. About in 1905 north-eastern Ontario began to attract attention as a gold field and there has developed a gold mining industry that puts Ontario among the leading gold producing countries of the world.

The general dissemination of gold in Northern Ontario is indicated by the fact that at least 23 more or less distinct areas are recorded by Hopkins in his treatise on Ontario Gold Deposits (Ontario Department of Mines, Vol. XXX, Pt. II., 1921). These areas are scattered with fair uniformity from the Quebec boundary to the Manitoba line. This general occurrence of gold together with the occasional discovery of pockets of extraordinary richness has been a fertile encouragement too often leading to disastrous results. Ontario gold-mining projects acquired a bad name, the whole district was condemned, but the fallacy of the conclusion is seen in the fact that Ontario now ranks high among the gold-producing countries of the world. Faith in the western mines is still to be found, money is forthcoming to open some of the old mines in the Lake-of-the-Woods district, and a shaft is being sunk to test the Red Rock property in the Wahnapitae camp. Thirty years ago I saw masses of quartz from this region that could not be smashed by sledge hammer owing to the content of gold.

The gold deposits of Ontario seem to be genetically related to intrusive rocks varying in age from Keewatin to Keweenawan, but it is now believed that all the great deposits are associated with Algoman granite or porphyry where these rocks have penetrated the pre-Huronian complex, particularly the Keewatin basalt schists and the Timiskaming sediments.

The now famous eastern gold areas lie along two main belts in which the conditions are somewhat different but in both of which the gold occurs in association with Algoman intrusives. The northern belt is dominated by the Porcupine group and the southern by the Kirkland Lake. The production recorded from these two groups to the end of 1924 is shown in Table IV.

In 1924 the mines of the Porcupine group (chiefly five) produced gold to the value of $22,266,894, the total production of the field to that date being $136,459,187 (from 1910). In the Kirkland Lake area, in 1924, six mines produced $3,593,433 in gold, the total production since 1913 being $14,085,272.*

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* Some disparity in figures may be noted: this is due to exchange and to value of silver in the gold.

TABLE IV.
GOLD PRODUCTION OF ONTARIO.

Year.	Total Production. $	Porcupine.		Kirkland Lake.	
		$	Per cent.	$	Per cent.
1866-1891	190,258	—	—	—	--
1892-1909	2,509,492	—	—	—	--
1910	68,498	35,539	51.8	—	—
1911	42,637	15,437	36.2	—	—
1912	2,114,086	1,730,628	81.8	—	—
1913	4,558,518	4,294,113	94.1	65,260	1.2
1914	5,544,979	5,206,006	93.8	114,154	2.0
1915	8,501,391	7,462,111	88.6	551,069	6.5
1916	10,339,259	9,391,408	90.8	702,761	6.8
1917	8,698,735	8,229,744	94.5	404,346	4.6
1918	8,502,480	7,767,907	91.4	632,007	7.4
1919	10,451,709	9,941,803	95.1	486,809	4.7
1920	11,686,043	10,597,572	90.7	1,033,478	8.8
1921	14,692,357	13,103,526	89.5	1,524,851	10.4
1922	20,579,569	18,374,658	89.3	2,159,581	10.5
1923	20,136,287	17,313,115	85.9	2,647,630	13.1
1924	25,669,262	22,135,534	86.2	3,446,632	13.4
Total*	154,285,560	135,599,100	87.8	13,768,578	8.9

*Preliminary figures.

In the Porcupine field, in 1924, 2,642,113 tons of ore were milled and in the Kirkland Lake field 225,571 tons. With 8,000 to 8,500 tons a day being milled in the Porcupine field the disposal of the slimes is becoming a matter of difficulty as all the available hollows have been filled.

The first three months of 1925 show a substantial progress and a new record for gold production in Ontario. It is officially stated that $6,949,636 was produced as against $5,735,882 for the corresponding period of 1924. Six mines at Porcupine and five at Kirkland lake contributed to this result, adding the gold recovered from the nickel copper ores, Ontario has a record of $6,992,533 for the first three months of 1925.

Five companies with a total capitalization of $40,000,000 paid during 1924 dividends to the amount of $6,465,043 ; in all, to the end of 1924, $38,853,911.

The Hollinger mine alone has produced nearly $84,000,000, the Dome $27,000,000, and the McIntyre $20,000,000. The first-named is one of the world's greatest gold mines with ore blocked out above the 3,000 foot level to the value of $450,000,000 (£100,000,000). In this mine as in others in the group the walls are self supporting, there is no rise in temperature with depth (47° in summer, 42° in winter), there is no more water than just enough to keep down the dust, and no difficulties of ventilation have been experienced.

It is somewhat surprising that the extraordinary richness of this gold-field is not more generally known. Writing in 1923, Mr. J. M. Keynes states " A quarter of a century has passed since the discovery of an important deposit (gold)."*

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* John Maynard Keynes: A tract on Monetary Reform, p. 165, 1923.

IRON.

The pre-Cambrian rocks of Wisconsin, Minnesota and Michigan have yielded iron ores of the highest grade in phenomenal quantity and with comparatively little difficulty in mining. These ores occur at various levels in the pre-Cambrian complex—from the Keewatin to the Animikie. Roughly speaking the great ore bodies are all due to secondary concentration of iron derived from original ferruginous sediments which constitute the "iron bands".

Naturally the hope has long been entertained that similar ore bodies would be found in the far greater areas of similar rocks in Canada. Iron-band rocks have been traced for miles, in great arcs, from the Lake-of-the-Woods to the Quebec boundary, and diamond drilling has been resorted to in attempts to locate concentrated ore masses of size; hitherto, however, no permanent success has been achieved.

The Animikie rocks, the greatest producers in the United States, occur under seemingly similar conditions in the Port Arthur district of Ontario. It seems unlikely that these rocks are devoid of commercial deposits of iron ore. Recent explorations are strengthening this belief and much attention is now being directed to the region with confidence that workable deposits will yet be unearthed.

Most of the Ontario iron bands are located in the Keewatin rocks and many discoveries of iron ore have been made. In all cases, however, the ore has proved to be of low grade or to occur in quantities too small to justify the establishment of a permanent mining industry.

Despite the failure to date of large, high grade deposits, iron ore has been raised in considerable amount. The Helen and Magpie mines of the Michipicoten district yielded about 4,000,000 tons of high-grade ore, and diamond drilling in their vicinity has revealed masses of low-grade carbonate ores measurable in hundreds of millions of tons. These carbonate ores can be beneficiated by sintering but attempts to apply this process at the Magpie mine have not met with success.

The Moose Mountain mine near Sellwood in the Sudbury district is another example of very extensive but low grade deposits; the ore bodies have a superficial extent of more than 3,000,000 square feet and are estimated to contain 38,655,000 tons of ore for each 100 feet of depth. The raw ore, while variable, consists of grains of magnetite scattered through rock matter; it averages less than 40 per cent. in iron and more than 40 per cent. in silica, but sulphur and phosphorus are both low.

Beneficiating is necessary to put these ores on the market; briquetting has been tried and thousands of tons have been shipped but a permanent success has not been attained.

The reason for the apparent failure in both the Michipicoten and the Moose Mountain areas is evident; the cheaply-mined, high grade American ores render impossible at present the exploitation of low grade deposits yielding ores requiring beneficiation.

The location of high grade secondary deposits along the iron bands is a matter of much difficulty; exposed ores are weathered away and, if such occur, they are buried under lakes and muskegs; unexposed ore bodies can be located only by means of diamond drilling. It required a long time and many failures to lead to the discovery of the remarkable gold deposits. It is not unlikely that the development of iron mining will show a similar history, in any event we are looking with confidence to the eventual discovery of large bodies of high grade iron ores. Even should such bodies never be located, the great masses of low grade ore are an asset which the eventual depletion of the Lake Superior ores will in time make valuable.

The Government of Ontario recently appointed a commission to inquire into the iron ore situation; as a result of its report an Act has been passed authorizing the payment of a bonus of one cent per unit of iron on ore raised in Ontario. This action of the Government indicates the confidence that is generally felt in the future of the iron-mining industry in Ontario.

In connexion with the metallurgy of iron it is interesting to note that the Miner Branch at Ottawa is investigating methods of producing metallic iron by electrolysis of pyrrhotite and pyrite ores.

COPPER.

The actual production of copper at the present time is confined to that of the Sudbury nickel-copper ores already referred to. Copper ores, however, are widely scattered in the mineral areas of the Canadian Shield. Small quartz veins carrying chalcopyrite are common and greater veins were formerly mined on the north shore of Lake Huron. It is thought that with the opening up of the country many of these small deposits could be worked to advantage by shipping the ore to custom smelters established at favourable points.

It is to be remembered, also, that the formation yielding the native copper of Keweenaw point in Michigan extends into Ontario and that native copper is known on Isle Royale, on Michipicoten Island, and at points along the north shore of Lake Superior. One need not be unduly optimistic to predict that workable deposits of native copper will yet be located in this district.

COBALT.

(and Arsenic).

The ores of the Cobalt district, while mined primarily for silver, yield large quantities of cobalt and arsenic. In the early days of hand-picked silver these substances were regarded as a nuisance, but they are now systematically recovered at plants situated at Thorold and at Deloro in southern Ontario.

Cobalt is exported as metal, as oxide, and in the form of various salts. In 1924, the value of cobalt products was $1,421,827 and of arsenic white $309,108.

In this connexion it might be mentioned, also, that there was in 1924 a recovery of bismuth from the Cobalt ores to the value of $16,079.

LEAD.

Small veins with scattered crystals of galena are not uncommon throughout the mineral districts of Northern Ontario but no real production of lead has been recorded. It is interesting to note however, that the old Victory mine near Garden river is now being reopened and a campaign of diamond drilling planned to ascertain the size and nature of the ore body.

On the Quebec side of Lake Timiskaming highly argentiferous galena occurs and a lead mine is being profitably worked at Galetta in southern Ontario. Northern Ontario is not devoid of possibilities as a producer of lead. The same may be said of zinc, for mines have actually been worked for this metal but without great success.

METALS OF THE PLATINUM GROUP.

It has long been known that the nickel-copper ores of Sudbury contain small amounts of gold, silver, platinum, palladium, rhodium, ruthenium, and iridium. In the early days of the industry these metals were not separated from the copper and nickel, but modern metallurgical methods permit their recovery, particularly the electrolytic methods and that of the Mond Nickel Company.

The production from the Sudbury field during the past five years is indicated in the following table :—

TABLE V.

PRODUCTION OF PRECIOUS AND RARE METALS FROM THE SUDBURY FIELD FOR A PERIOD OF FIVE YEARS.

	1920	1921	1922	1923	1924	
	Ounces.	Ounces.	Ounces.	Ounces.	Ounces.	Value $
1. *Gold	1,261	4,537	2,094	3,574	4,125	84,646
2. Silver	119,839	50,341	50,239	100,982	122,889	81,843
3. Platinum	8,345	5,412	4,802	6,810	9,181	1,069,201
4. Palladium	10,199	7,729	6,862	8,511	8,923	771,176
5. Rhodium, Ruthenium Osmium and Iridium	522	277	124	304	593	51,120
Total Platinum Metals	19,066	13,814	11,788	15,625	18,697	1,891,497

*Includes small recoveries of group 5 by the Mond Nickel Co.

As the world's production of these metals (exclusive of gold and silver) in 1921 is given as 52,605 ounces, Ontario's contribution of 18,697 ounces in 1924 should raise her to third, if not to second place, among the world's producers. In 1921 Colombia produced 31,220 ounces, Russia 18,180 ounces, Australia 1,852 ounces, and United States 875 ounces.

SULPHUR.

Iron pyrites is used for the making of sulphur dioxide in the manufacture of sulphuric acid. This mineral occurs in quantity at several places in Ontario. 37,000 tons were shipped from the Magpie iron mine in Northern Ontario and deposits are being actively mined at Sulphide and other places in the pre-Cambrian of eastern Ontario. Cheap native sulphur from the Southern States at present militates against the exploitation of many deposits of pyrite in the north.

Enormous quantities of sulphur dioxide have been voided into the air from the roast heaps at Sudbury; this is not only a serious economic loss but a menace to the vegetation of the surrounding district. It is to be noted with much pleasure that the Mond Nickel Company are now installing an acid-recovery system in their plant at Coniston.

OTHER MINERALS.

The pre-Cambrian area of southern Ontario is a region remarkable for the number and variety of its economic minerals. As this region is without our present field it will suffice to enumerate the more important of its products; graphite, mica, asbestos, apatite, molybdenite, feldspar, marble, corundum, talc, barite, fluorspar, and garnet; formerly also, gold, iron, and arsenic.

Some of these substances, *e.g.* asbestos and barite, have already been located in the northern region and it is not unreasonable to expect that many more will yet be found. There are, however, a few occurrences, not listed above, to which I would briefly direct your attention.

Gypsum in thick beds of great purity occurs for miles along the Missinaibie river and on other streams to the east. While the difficulties of transportation render these deposits useless at present, they must be included among the resources of the country and will doubtless prove of great value to generations yet to come.

The Palæozoic plain bordering Hudson Bay is a region of interminable muskegs dotted with dwarfed black spruce. In these muskegs peat has accumulated to an amount that is truly enormous but entirely unestimated at present. There are thousands, if not tens of thousands, of square miles of peat bogs of undetermined depth. I can only say that I have seen, on lakes and streams south of James Bay, where the clay banks have broken down, vertical exposures of peat up to twenty feet in thickness.

Beautiful porphyries occur in many of the igneous dykes, particularly in the region north of Larder Lake; agate, amethyst, and jasper of great beauty are found along the north shore of Lake Superior, and the syenites of Port Coldwell with their iridescent felspars rival the famous stones of Scandinavia.

Finally, we must include diamonds, among the undeveloped, or rather undiscovered, resources of northern Ontario. Several diamonds have been found in the drift of the northern United States the source of which must have been in Ontario. It is far from visionary to state that somewhere in the northern wilderness occurs a diamond-bearing eruptive. It has always been my practice to examine carefully for diamonds any ultra basic rock encountered.

GENERAL.

Disregarding the many minor occurrences of mineral deposits, low grade ores at present incapable of being profitably worked, and substances of future value only on account of the present lack of facilities of transportation, we have in Northern Ontario gold, silver, nickel, copper, and cobalt, in deposits of proved commercial value. All the losses and disappointments of the past do not gainsay this statement, nor do they justify an unhopeful view as to the future development of the mineral industry in this territory.

The mineral belts are of vast extent, the country is heavily wooded, prospecting is difficult, and development work necessary, but the geological conditions are favourable and the knowledge of the existing proved deposits is a spur to effort and a promise of eventual success.

Most of the money lost in Northern Ontario has disappeared in the pursuit of gold. There are literally hundreds of abandoned shafts and workings between the Quebec boundary and the Lake-of-the-Woods. This is but an evidence of the general dissemination of gold. The failures are due to bad judgment, frequently accompanied by incompetence and extravagance, and the same is true of any mining district in the world. This general dissemination of the precious metal has emphasized the difference between a prospect and a mine; it has also emphasized the necessity for extreme caution on the part of the investor. One cannot blame the prospector or the holder of an undeveloped property for seeking capital to investigate his claim. He does so, usually, in good faith for your prospector is always an optimist or he would not be a prospector.

In future there should be less money lost in unprofitable gold mines. The discovery that the great deposits are related to Algoman granites should go far to prevent misfortunes, and the prevailing custom of exploration by diamond drill before sinking shafts should minimise the expense of preliminary investigations.

It has been said that there are three general ways of procedure in financing mining and exploration as follows:

1. Established mining companies; these usually maintain an exploration department.
2. Exploration companies and syndicates; these usually investigate prospects and develop them to the point of requiring a serious capitalization for actual production.
3. Companies that take over prospects and sell stock to the public for funds to investigate, or to develop, or to actually mine.

If I may be allowed to offer advice to the British investor I should favour the first of these methods as the most conservative and the least likely to result in loss. The stock of successful mining companies, however, is usually held at a high figure commensurate with the dividend and the value of money.

The third method, except in exceptional cases, is dangerous for the investor at this distance from the field; further, it is the method that gives scope to the unscrupulous promoter.

The second method, that of exploration companies, should appeal to the British investor desirous of assisting in the mineral development of Northern Ontario. Companies of this kind may send out their own prospectors, or keep in touch with private prospectors and owners of undeveloped properties. They can examine, at relatively small expense, a large number of undeveloped or partially developed prospects in the hope that a new Cobalt, or Porcupine, or Kirkland Lake may fall into their hands.

It is evident that the success of companies of this kind depends very largely on the ability of the officer in charge. Above all, he must be a man of good judgment and this faculty can be acquired only by a familiarity with the conditions throughout Ontario. The type of man for this work is the *economic geologist* who may be defined as a geologist trained particularly in the lore of ore bodies and with some knowledge of mining engineering, or he may be defined as a mining engineer with the necessary training in geology.

Before closing I should like to direct your attention to a subject that is but indirectly connected with the substance of this address but one that is, nevertheless, germane to the mining industry of Canada.

SIR WILLIAM LOGAN.

Lower Canada (Quebec) and Upper Canada (Ontario) were united to form the Province of Canada in 1841, and in 1842 Mr. William Edmond Logan, born at Montreal in 1798, was appointed to make a geological survey of the new province, a region stretching from the Gaspé peninsula to beyond Lake Superior, and extending northward an unknown distance into the inaccessible wilderness.

Sir William Logan with few assistants and without adequate financial support laboured at this tremendous task for more than a quarter of a century retiring in 1869 shortly after the Act of Confederation established the Dominion of Canada.

Logan is justly regarded as the "Father of Canadian Geology," in that he established the general stratigraphical succession throughout this great area and laid the foundation for the nomenclature of the pre-Cambrian rocks of the Canadian Shield.

While essentially a stratigrapher, Logan was not unmindful of the fact that it is the economic aspect of geology that opens the public purse. Consequently we find that references to ore deposits appear throughout his reports and that, in addition to such references, 165 pages of the comprehensive report of 1863 are devoted specifically to economic geology.

While willing to encourage serious attempts to exploit the mineral wealth of the country, Logan set his face against misrepresentation and was always averse to expressing his own opinion as to values although frequently solicited in that respect. He was accustomed to meet enquiries of this kind by the statement "I am a geologist, not a mining engineer." He had, nevertheless, a strong faith in the future of the mining industry; this faith has been justified and, with the partial breaking down of the distinction between geologist and mining engineer, has come the desire on the part of the latter to recognise the services of Logan to the mining industry of Canada.

In 1913, as a mark of appreciation of Logan's services to geology a bronze memorial was erected at Gaspé and replicas were placed at other points in the Dominion. A movement is now on foot to recognise his services to mining by having his portrait hung at some suitable place in London. An excellent picture is in the possession of the Royal Canadian Institute at Toronto; the Canadian Institute of Mining and Metallurgy proposes to raise the funds necessary to have a copy of this portrait hung in London and possibly also in New York.

Before I shall have the pleasure of again being in London, I hope that you will have here a lasting memorial to the distinguished pioneer who was not only the "Father of Canadian Geology," but the father of the Canadian mining industry as well.

In closing I would state that I am highly honoured in having the opportunity of addressing the Royal Society of Arts. I regret that the short time allowed me for preparation has not permitted an adequate presentation of the subject. I shall be content, however, if I shall have assisted in convincing you of the great potential wealth of Northern Ontario and of showing that, if the failures have been many, the rewards have been correspondingly great.

The preparation of this address would have been impossible except for the kind co-operation of Mr. W. D. Dalglish, the officer in charge of the Canadian Mineral Exhibit at Wembley, and for the great kindness of Sir Richard Redmayne who placed the resources of the Imperial Institute at my disposal. To Sir Richard Redmayne and to Mr. Dalglish I desire to express my sincere thanks.

DISCUSSION.

The Chairman (Sir Richard Redmayne), in opening the discussion, mentioned that Sir Alfred Mond, who was abroad, had written expressing his regret at his inability to be present. The paper, the speaker said, gave a telling description of the bad state the nickel industry got into in the Sudbury and other districts, owing to the many rival interests and the want of capital and proper methods of organisation, a state of affairs which continued until the great Mond interests stepped in, consolidated the work, and developed the nickel industry until it became the success it now was. That was an example in miniature of what might be done in the case of the coal mining industry in this country. If only the colliery owners would form in group combinations, with a view to concentration of effort, greater organisation, and the introduction of improved methods within the groups, he thought it would be found that the industry (which, after agriculture, was the greatest in the country) would soon be put on its feet. What he suggested was by no means nationalisation ; quite the reverse. Cheap coal was the life-blood of the nation ; oil would never be a serious rival to coal, because for one thing there was not enough of it. Coal formed an important part of the cost of operating other industries, and was at the present time far too dear, yet the wages earned by the miners were by no means excessive. What was required was a drastic re-organisation.

There were one or two matters in the paper in regard to which he would like further information. The author referred to the fact that one of the great granitic masses was productive of gold and other valuable minerals, while the other was not, and said that at present there was no guide as to whether an individual one was gold bearing or mineral bearing or not, but that possibly a means might be discovered whereby the presence or absence of radioactive minerals would be a guide in that direction. He would like to know why and how.

The author put the area which might be favourably prospected in Ontario at, in round figures, 50,000 square miles, but a great deal of that was under swamps and lakes, and he thought there would be great difficulty in prospecting under a covering of, for example, twelve feet of peat, under which again would come the earth on which the peat moss grew. It might be possible, by means of the diamond drill, to do something, but that was a fairly costly method of prospecting to employ, for if one took cores, say, a mile apart one might miss the gold vein altogether.

He was interested un the author's statement that there was no rise of temperature in the mines in the Porcupine region with increase in depth. The average rise in temperature in this country was about 1°F. for every 60 feet of depth after the first 100 ; the average in South Africa was about 1° for every 200 feet, while in the Lake Superior region the rise was still smaller, amounting to only a few degrees at a depth of 4,000, to 5,000 feet. He would be interested to learn whether the author meant there was no rise at ail, or merely an infinitesimal increase.

He was sure the Society was greatly indebted to the author for his admirable and interesting paper.

Mr. A. G. Charleton said he had listened to the paper with the greatest interest. He had always taken a great interest in Canadian mining, as in 1881 he was assistant superintendent of the first successful gold mine in Canada. The ore that had to be dealt with was very refractory, but averaged about 18½ dwt. gold per (short) ton. and consisted of sulphide of arsenic (mispikel) in quartz-veins, in syenitic granitic country. " Horses" of micaceous and talcose slate are found in the veins and the " walls " are of the same nature. As far as gold was concerned it was not a great success, but the arsenic works which were established became the largest at that time in the world, and produced a great output. When in Canada with the International Geological Congress in 1913, he had the pleasure of seeing the Hollinger mine, and was greatly impressed with the potentialities of that region

Major Henderson Scott complimented the author on his clear exposition of the mineral deposits of Ontario and said he knew Ontario rather well, and thought the area available for prospecting was even greater than the author had indicated.

Mr. H. S. Spence said a great deal of the pre-Cambrian area might be regarded as barren and probably unproductive, so far as minerals were concerned, but the author had brought home the fact that there were fifty thousand odd square miles of productive rocks, and personally he shared the author's optimism in that respect.

Mr. R. à-Ababrelton said that within living memory gold mining took place on a very large scale in California, then in Australia, then in South Africa, and now, judging from the remarks of Professor Parks, he did not see why Canada should not become the most important area in the world from the point of view of gold production.

Mr. Byron Brenan, C.M.G., proposed a hearty vote of thanks to the author for his paper, and to the Chairman for presiding. Of all the metals, except gold, which the author had mentioned, it might be said that the more of them the better; but, so far as he could see, the more gold the country had the worse off it was.

Professor Parks, in reply to the discussion, said the Chairman had inquired about the possibility of distinguishing the two kinds of granite. The great granite masses which were intruded into the sedimentarier came up at different times during the early pre-Cambrian period. There was an earlier mass of granite which is sometimes called the Laurentian, and a later one called the Algoman, but there might be others, and it was not possible to tell them apart. It is now fairly well known, however, that only the Algoman granite introduced the gold, and not the Laurentian; consequently any means of telling Algoman from Laurentian granite would be of great value. It has been shown of recent years that any mineral containing uranium breaks down in the course of time, one atom of uranium giving rise to one atom of lead and eight atoms of helium. The rate at which that disintegration takes place is known, and what is called a "half-value period" has been established, and is expressed in a definite number of years for any particular element, radium, uranium and thorium more particularly. Given a uranium-bearing mineral from each of the granites it is evidently possible to determine their relative ages and thus discriminate between the older Laurentian and the younger Algoman. The method in question, however, is not yet perfect enough to be altogether reliable.

With regard to there being 52,000 square miles available for prospecting in Ontario, he had tried in his paper to bring out the fact that while there were about 52,000 square miles of metal-bearing rocks, that area from a prospector's point of view was considerably reduced, owing to swamps, lakes, and soil. The area immediately available was less than the figure he had mentioned.

The temperature in the Hollinger mine was, he believed, 42° almost constantly throughout the winter and 47° in summer.

NOTES ON BOOKS.

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The Microscope. By S. H. Gage. 14th Edition. New York: Comstock Publishing Co. $3.50.

While many minor improvements and corrections have been made in this edition, the most important feature is a new chapter dealing with dark-ground illumination. As is well known, valuable advances in this field have been made in recent years, and the subject is here carried right up to the present date in the most painstaking and practical fashion.

In looking at the book as a whole, one cannot fail to be struck by the comparative lack of interest shown in questions of microscope design. In this country, as a general rule, these questions are keenly discussed and copiously illustrated, so that in our own text-books the effect for whole chapters together is almost that of a critical commentary on a composite manufacturers' catalogue. In America there seems to be more standardisation ; apparently one buys one's " outfit " from one or other of the two great American firms of microscopic opticians and takes its design for granted.

In other directions also there is revealed an extraordinary divergence of opinion between the experts on the two sides of the Atlantic. Thus Professor Gage (pp. 45, 48) believes so strongly in daylight illumination, especially in the form of a north light, that if he cannot get the thing itself he will go to endless trouble to imitate it with artificial light as closely as possible; while Nelson (as quoted by Coles, *Critical Microscopy*, 1921, p. 21) remarks : " One hour of steady hard work with the microscope by diffused daylight will tire you more than a whole day's work in a dark room by lamp-light."

Again, in the matter of critical illumination, Professor Gage recommends the use of ground glass to diffuse a filiform illuminant, or for other reasons, even with high powers. Compare this with the dictum of Hind and Randles (*Photomicrography*, 1913, p. 22) : " Ground glass is never used when critical illumination is required."

Connected, perhaps, with the author's opinion on these two matters is the extreme paucity of information on the subject of artificial illumination in general. Even in the chapter on photomicrography, no reference whatever is made either to the mercury vapour lamp or to the Pointolite lamp, though elsewhere in the book the name of the former receives a bare mention once, and that of the latter twice.

One would judge that pure photomicrography is of less moment in American practice than in our own. There is a long and interesting chapter (sometimes straying far indeed from the subject of microscopy) on methods by which optical projection, in one form or another, is assisted by the artist's pen.

The chapter on vertical illumination and metallography has been rather regrettably omitted from the present edition, and the section on polarised light is so short as to be, one would think, of little practical use to a student ; while on the other hand there is given in connexion with the micro-spectroscope a quantity of physico-chemical information which seems somewhat out of place. Altogether, one cannot avoid the impression of a certain lack of balance and co-ordination throughout the book, which is not lessened by the remarkable way in which unrelated subjects are sometimes grouped into chapters ; as in Chapter III, which begins with sections, in the order named, on : objectives in general, the difference between images of coloured and colourless objects, the binocular microscope, the care of the microscope, and so on.

Excellent features are the small lists of further literature at the ends of chapters, and the general bibliography at the end of the book, though the latter has not been kept quite up to date, and seems to omit reference to books on photomicrography. The prices of modern works are given in this bibliography, save in a small section devoted entirely to recent publications, which seems hardly the place in which to omit them.

ECONOMIC CONDITIONS IN INDIA. By P. Padmanabha Pillai. London : George Routledge and Sons, Ltd. 12*s*. 6*d*. net.

This volume of 330 + xviii pages forms No. 78 in the series of monographs issued under the auspices of the London School of Economics, and the thoroughness with which Dr. Pillai has studied the general history of origins or developments as bearing on India's sentiments, habits and needs, affords a good basis for applying the economic lessons of the great war; the author's position on the secretariat of the League of Nations giving him opportunities for maturing his views on many aspects of doubt.

India is now face to face with a rapid increase of population and consequent greater demands on the soil; moreover, in a country where the rainfall is precarious in amount and ill-distributed (pp. 36, 61), and the author, while generally admitting " that an old agricultural country like India is more susceptible to the influence of the law of diminishing returns than new or industrial countries," hopes that the " new agriculture " may intervene favourably, but various complications new to India appear to be " outcomes of the Educational policy of the British Indian Government" (p. 37); these outcomes, including unemployment among the intellectual classes and a drift towards political activities (p. 37).

A feature of Dr. Pillai's volume is a careful search for secondary or ultimate consequences of changing social conditions and of legislative experiments; the author's mental constitution evidently including a notable infusion of that caution as to deductions from the sequences to experimental legislation which was enjoined by writers of the ancient peripatetic school, by Bacon in his essay on " Innovations " and elsewhere, but perhaps more trenchantly and definitely by Herbert Spencer, who has so frequently called attention to the wide contrast between intention and realisation in experimental and remedial legislation, the unexpected generally predominating in the long run, notwithstanding early indications of the law fulfilling the intentions of its promoters.

In the broad spirit of historical study, integrated with present-day experience, Dr. Pillai gives us much which bears on the vexed question of protective duties on imports, with the when and why such duties may be desirable or undesirable; and in this aspect pp. 318 to 328 may be read with special advantage. State action generally as contrasted with private enterprise and capitalisation are considered in a very fundamental manner in relation to Indian needs, and it is interesting to read, on p. 311, of a limit at which it has been assumed by the Ootacamund Conference that a new State industry in India is likely to remain a " petty and ineffective plaything," or become " a costly and hazardous speculation." As an observed fact Mr. Pillai finds that an increase of wages in India has not proved advantageous, but has merely promoted idleness, the worker being contented to work shorter time and take the same total (p. 246), but he gives his reasons for regarding higher wages a *sine qua non* for the efficiency of Indian labour. A minimum wage for each industry is, after the study of many facts, regarded as impracticable in application and fallacious in theory, as involving an arbitrary determination by a few outsiders of the standard of living, p. 245.

Indian personal finance, in relation to borrowing and banking, are treated of at length in references to the lesson of Germany's pre-war banking system, and the Pownall dictum, p. 295.

Dr. Pillai's volume owes its value to its distinctively intricate character, and the way in which issues likely to escape notice are shown to bear on the main questions; it seems a pity, therefore, that those to whom the MS. was entrusted for seeing through the press, during the author's absence on duties connected with the League of Nations, did not arrange for someone to index and cross reference the volume, especially as the work has been awarded a grant-in-aid by the Indian Government.

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PROCEEDINGS OF THE SOCIETY.

HOWARD LECTURES.

MOTOR FUELS.

By J. S. S. BRAME, F.I.C., F.C.S.

Professor of Chemistry, Royal Naval College, Greenwich. Past President, Institution of Petroleum Technologists

LECTURE I.—*Delivered April 20th, 1925.*

The subject of motor fuels is one which has been widely discussed from its various aspects before the technical societies interested, and in the technical press. A large amount of valuable research work has been done in this country by Ricardo, Ormandy and Craven, and other investigators, and recently the Institution of Automobile Engineers, with assistance from others, has published a most valuable report on the work of the Empire Motor Fuels Committee, and summarising other recent work in this country and in the United States of America. In the last named country, as would be expected from the great use made of automobiles, chemists and engineers have carried out a great deal of very valuable research work.

It seemed to me, therefore, a very appropriate time to review in these Howard Lectures the whole subject, considering in the first place the ways in which the greatly increased demands for motor spirit have been met, hitherto, and the prospects of meeting the undoubtedly still greater demands of the near future by alternative, or, as it is better expressed, supplementary fuels. Further, how, as the result of this research work, we have acquired a good knowledge of the relative merits of the different components of our various types of motor spirit, knowledge which can be applied to their improvement and the production of blends which impart most of the best characters to the mixtures. Again much light has been shed upon the important question of the more efficient utilisation of our motor fuels.

It is particularly appropriate that the opportunity for discussing these questions should have been afforded by the Royal Society of Arts, for it was in this hall, just fifteen years ago, that the late Professor W. Watson gave a series of four Cantor Lectures which were almost the first to be delivered on the scientific results from experimental work on the petrol engine.

The rapid development in the use of motor cars throughout the civilised world, and the development of aviation, an extension of which is bound to make further great demands on suitable fuel in the near future, have necessitated an enormous increase of production in recent years. Dr. W. R. Ormandy credits Lord Montagu of Beaulieu as making an estimate some years ago of the English requirements reaching 20,000,000 gallons per annum. Only last month the approximate figure of 500,000,000 gallons was given in the House of Commons as the consumption for 1924! It is almost beyond speculation what the world's demands may be ten years hence.

An estimate of the number of motor vehicles of all classes in 1912 gave the aggregate for the world at 1,360,000 and an estimate for 1924 at 20,380,000. Thus whilst the motors were 15 times the number the crude oil output was approximately only 3 times.

So far the demand for motor spirit has been practically met by the petroleum industry. The output of crude oil has been nearly trebled in the period 1912—1923 (Table I).

TABLE I.

Crude Oil Production — The World.

	Metric tons.
1912	47,655,900
1922	133,702,000
1923 (estimated)	133,544,000
1924 (estimated)	137,642,000

A most important consideration is the available surplus left for export after home consumption in the chief producing countries has been provided for. In a country like the United States of America, with approximately 15 times the number of motors of all classes in use as compared with this country, the exportable surplus per cent. on the total production is comparatively small. In 1910 the per capita consumption of motor spirit in the U.S.A. was 96 gallons, in 1921 it was 230 gallons. On the other hand, in remote countries like Sarawak or Persia a much higher per centage of the output is available for export. Thus while from the U.S.A. and Mexico the export (all grades) is 20-22 per cent., for the East Indian Archipelago it was 62 per cent. (1921) and 56 per cent. (1922) and for Persia 81-85 per cent. of the production.

The sources from which we draw supplies of motor spirit, and all other petroleum products, is a matter of vital importance from the point of view of national safety. The whole has to be transported by sea. To-day petroleum products, particularly motor spirit, are essential to military operations. Mechanical transport has largely superseded all other forms of transport; tanks and aeroplanes are dependent on ample supplies of motor spirit. Any country failing to keep up its supplies would be very seriously handicapped, indeed outclassed. Dependence on one particular line of supplies, either from the East, via the Suez Canal or from the West, involving transport across the great Atlantic, might in some circumstances lead to disaster. It is all to the advantage of this country that there has been a wider distribution of the area of supply in recent years, and the discovery of new oil fields in both the Eastern and Western hemispheres is a matter of great importance to Great Britain.

The change which took place in the distribution of our sources of supply between 1913 and 1918 and later between the Armistice and 1922 are well illustrated in Fig. I, the data having been collected from a paper by Admiral Sir Edmund Slade before the Road Traffic Conference (1923).

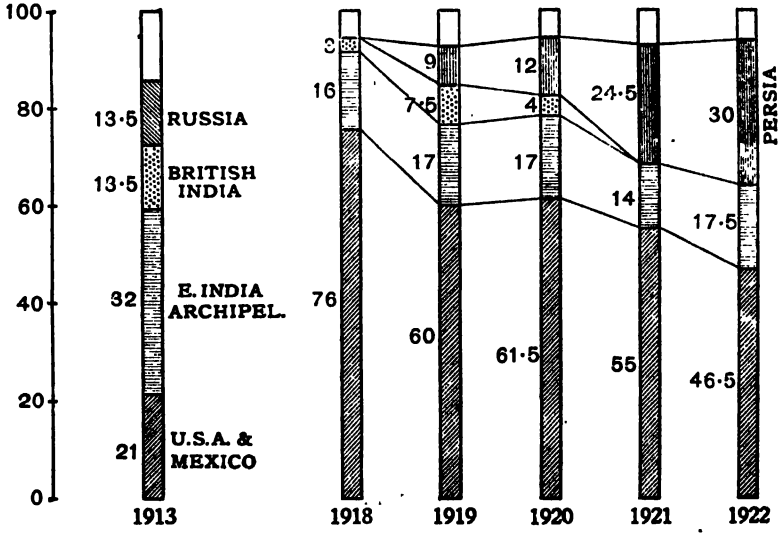

FIG. 1.—Sources of Motor Spirit used in Great Britain.

It is astonishing to find that no statistics are available as to the actual quantity of motor spirit used annually in the country. Data are available from the Customs returns of the quantity of "motor spirit" (including crude naphtha) imported and the re-exports, so that a balance of that retained for home use can be made, but there is to-day a very considerable production from crude oil distilled in this country, and which does not appear in the usual returns, the figures for which may even be very misleading. Thus, those for Persia show that the import fell from 64,692,532 gallons in 1922 to 17,366,132 in 1923, and to an estimated figure of 12,000,000 gallons in 1924, whereas the total Persian spirit marketed has materially increased (Fig. I.).

Important as the increase in production of crude oil has been in contributing to an increased output of petrol the demands could not have been met solely by increased production directly from the crude oil. Producers turned their attention to increasing the yield of the petrol fraction from the crude oil, and with marked success. According to T. A. Boyd (J.I.E.C. 1924, **16**, 1004) in 1913 the United States produced about 1,100 million gallons of petrol, or naphtha, representing 12.5 per cent. of the crude oil, in 1923 the output was approximately 7,500 million gallons, representing approximately 30 per cent. of the crude. The motor spirit fraction is certainly to-day by far the most important fraction of the crude oil and to raise the average yield to more than twice what it was ten years ago was a technical advance of the highest importance.

The principal contribution to this increased yield has been the extensive introduction of "cracking" processes, a second factor of great importance the separation of high-grade petrol from casing head gas. Petrol obtained by the ordinary methods of distillation, which are dependent upon evaporating off and condensing the vapours of the lower boiling hydrocarbons, yields what is known as "straight" petrol. By cutting the distillate at suitable points a petrol results having a certain range of distillation. There would be an obvious advantage in making the final boiling point as high as possible (usually it is about 190°C. in the best grade motor spirits) because the yield from any given crude oil would thereby be increased.

Petroleum motor spirit has indeed undergone very considerable modification in the effort to obtain the largest possible fraction from the crude oil. In 1907-09, for what is commercially known as No. 1 petrol, the average percentage distilling below 100°C. was 60 to 70; with a final boiling point of 125-130°C. In 1912 about 40-50 per cent. was common below 100°C, with a F.B.P. of 150-160°C. A number of the best known brands collected this year show 40 per cent. below 100°C., with F.B.P's. ranging about 180-190°C.

There is however, a practical limitation with present day engines to raising the final boiling point, because the "heavy ends" (high boiling fractions) escape complete combustion and dilution of the lubricating oil in the engine results, besides some secondary objections to such a proceeding.

Failing this way of increasing the average yield per gallon of crude oil recourse has been had to the two methods above referred to.

"CRACKED" SPIRIT.

Cracking is dependent upon the instability of the higher boiling fractions of petroleum oil when heated and the thermal decomposition results in the production of "cracked spirit," accompanied by much gas formation and free carbon. It necessarily involves considerable loss of material but has, nevertheless, proved a very valuable branch of petroleum technology.

From a census taken by the Oil Gas Journal (1924) it appears that in the United States of America there were 563 refineries of which 164 were equipped with cracking plant, and it has been stated that the present capacity of commercial cracking plants in the United States is capable of producing annually 2,250 million gallons of petrol, twice the total quantity produced in 1913. In 1920 Burton estimated the U.S.A. production of cracked spirit as 750 million gallons, or a little over 16 per cent. of the total output.

As indicating the important influence of the process on the economics of operating the refineries, on May 1st, 1924, 35 per cent. of those in which no cracking plants were installed were shut down, but only 10 per cent. of those provided with cracking plant.

In this country a cracking plant has been in successful operation during the last year at the works of the Medway Oil and Storage Company, Isle of Grain. It is a Cross plant and in March of this year 596,000 gallons of finished spirit was made. The raw material is a Russian kerosene and the yield of marketable spirit is 60-65 per cent. A full description of this plant will be found in *Engineering* (1925, **119,** 247 and 312.

Cracking processes have added very materially to the quantity of motor spirit yielded by a crude oil but their further development must be dependent upon maintaining a sufficient margin of profit. There are inevitable losses, due to gas and carbon formation, and also to what are commercially, at least, uncrackable residues (although these find use as fuel). There is the capital cost of the plant and the operating cost to be covered. Clearly the price of the finished product must be high enough to leave a margin of profit after the cost of the raw material and the conversion have been met. In practically all cracking plants an intermediate petroleum distillate is the raw material, that chiefly used being the "gas oil" fraction. Demands for this fraction come from the gas industry for the carburation of blue water gas. Further this fraction constitutes the highest grade of fuel oil suitable for use in Diesel and semi-Diesel engines. Great strides have been made in the introduction of Diesel engines and marine engineers look with confidence to a rapid advance in the utilisation of these engines for ships. This foreshadows increasing demands for suitable fuel, and although oils of lower grade, even certain residue oils, have been used successfully in Diesel engines, it is highly probable that for marine use generally a high grade distillate of the gas oil type will be insisted on for many years to come. The risk of serious running troubles or possible stoppage with engines running day in and day out for considerable periods on a cheaper grade of oil is one which ship-owners are not likely to incur. My own view is that the gas oil fraction (or Diesel engine distillate) is going to be in much greater demand and will probably become too valuable to crack, but simultaneously there may be an advance in price of the motor spirit which may maintain that margin which to-day makes cracking a financially sound proposition.

There is, however, the possibility of cracking residues from the distillation of crude oil, that is those portions remaining after the motor spirit and kerosene fractions have been removed. Unfortunately the use of such residues leads to greatly increased carbon production in the cracking plant and there appears to be only one design of cracking plant which is operating successfully on residue oils. It is in the development of plants which can deal satisfactorily with residues that the commercial future of the cracking process probably lies.

Cracked spirit is characteristically different from the "straight" spirit, chiefly in that it contains a fairly high quantity of unsaturated hydrocarbons. These are of at least two distinct types—those which are stable in the light and in presence of air, others unstable. The latter are generally regarded as di-olefines; they quickly turn yellow and form gummy polymers. It is very necessary that they shall be removed by suitable refining. Unsaturated hydrocarbons of the stable type do not appear to be any disadvantage in a motor spirit. Ricardo, in his variable compression engine, described later, used a cracked spirit quite successfully up to a compression ratio of 5.55/1. Further tests by the same authority of a cracked spirit produced by the Cross process gave a consumption of 0.458 pints per I.H.P. at the highest useful compression ratio (5.79/1), as compared with 0.475 pints per I.H.P. for an aromatic free petrol at the highest useful compression ratio (4.5/1). The writer has run a 4 seater car on a refined but unblended cracked spirit produced in the Cross plant for 170 miles and found the engine functioned as well as with the best aviation spirit. There was no indication of "pinking" or detonation on fair gradients and the miles per gallon was approximately the same as for straight No. 1 petrol, although unquestionable official trials have shown a decided increase in miles per gallon.

In general, cracked spirit is not used alone but is blended with straight petrol, and the large output of the American cracking plants which has come into use does not appear to have given rise to trouble in running. One objection may be urged against cracked spirit and that is its pungent and somewhat unpleasant odour; users in this country are so accustomed to a pleasant smelling spirit that they are prejudiced against any other, but after all, when the spirit is in the tank of a car it can seldom give rise to any unpleasantness. As far as the writers personal observation goes the exhaust is quite as sweet as from any other spirit, certainly sweeter than from benzole.

"CASING HEAD" SPIRIT.

The other source which has contributed considerable quantities to the total output of motor spirit is natural gas. Vast quantities of this gas are distributed for general use as a heating and lighting agent in Canada and the United States. Where the gas has been directly associated with petroleum, in addition to the not easily liquified hydrocarbons methane, ethane and propane, there are present the vapours of the lower boiling constituents of straight petrol. By compression these vapours are liquified and constitute the "Natural Gas Gasoline" or "Casing Head Spirit."

The growth in production of such spirit has been truly remarkable. In 1911 approximately 2,500 million c.ft. of natural gas was treated, yielding 6,100,000 gallons (Imperial) of spirit; in 1921 well over 500,000 million c.ft. of gas yielded the huge total of 374,540,000 gall. (Imperial). The average yield from the gas suitable for treatment in the United States is 2.5 to 2.9 galls. (Imperial) per 1,000 c.ft.; the richest gas yields 6.6 gallons.

The methods of extraction are (a) compression, with cooling, (b) washing out the vapours with heavy oils, (c) direct absorption by passing the gases through solid absorbents, such as the activated charcoal developed for use in gas masks. The two latter processes are rapidly taking the most prominent place. The liquid condensed by compression contains a high percentage of very volatile hydrocarbons and has to be "weathered" to allow of these evaporating, otherwise excessive pressures would be set up in containers.

Natural gas spirit may almost be looked upon as a super-petrol because of the high percentage of low boiling constituents it contains. Not only has its production been a direct contribution to motor spirit supplies, but indirectly it has enabled a larger proportion of the crude oil to be used as a motor spirit, since grades of naphtha with volatility a little too low for their inclusion in the ordinary straight petrol product may be blended with the highly volatile natural gas spirit and give a satisfactory mixture.

D. B. Dow, of the U.S. Bureau of Mines, gives the following distillation figures for a "raw" natural gas gasoline (sp.gr. 0.651).

I.B.P.	31°C	50 per cent. at	61
10 per cent. at	32.5	60 ,, ,, ,,	75
20 ,, ,, ,,	36.0	70 ,, ,, ,,	93
30 ,, ,, ,,	42.5	80 ,, ,, ,,	143
40 ,, ,, ,,	50.0	F.B.P.	143

Because of the very low boiling constituents the distillation loss was high—18 per cent.—and this accounts for the final boiling point corresponding with the temperature at which 80 per cent. of distillate was obtained.

Home production of motor spirit has been practically confined to the oil shale and coal distillation industries. In 1913 the Scottish shale industry produced about 29,000 tons, equivalent to some 8 per cent. of the home consumption. Production has tended to diminish and as the consumption of motor spirit has increased tremendously the shale spirit output in 1922 represented about 2 per cent. of our requirements. There certainly does not appear to be any probability of an increased output from shale until, perhaps, the very difficult problem of de-sulphurising the oil from the Dorset (Kimmeridge) and Norfolk shales has been solved.

MOTOR BENZOLE.

The coal distillation industries are, however, capable of adding materially to our requirements, and have already made large contributions. A good deal of prejudice against motor benzole has had to be overcome; it still lingers in some quarters, but in general benzole is accepted as a fuel with certain well-defined advantages and its production on the largest possible scale in this country is generally admitted to be highly desirable, and much valuable propaganda and research work on the production and use of motor benzole has been carried out by the National Benzole Association. Much valuable work in dispelling the early antipathy to benzole has been done also by the Royal Automobile Club, the Commercial Motor Users' Association and others, including the powerful advocacy of " The Motor."

Many estimates have been put forward for the amount of motor benzole this country is capable of producing, and very variable are the quantities arrived at. Tars vary widely in their yield of benzole; benzole, being a commercial article is produced in grades which differ very considerably from one another, and some authorities estimate in one grade, others in quite a different one, others simply say benzole without in any way indicating whether it even approximates to the specification adopted for " motor benzole." Without attempting any estimate of such problematic accuracy I propose taking some of the facts stated by the Fuel Research Board (1920) and last year by Mr. W. G. Adam at the World Power Conference.

Figures given by the Fuel Research Board (1920) for the production in 1918 were :—from gas works, 10 million gallons ; from coke ovens, 32 million gallons. For 1919 the total production was given as 20 million gallons.

The quantity of coal carbonised was given as 16.5 million tons at the gas works and 18 million tons at coke oven plants. The benzole (undefined) production in 1921 was 14 million gallons ; this on 34.5 million tons of coal is approximately 0.4 galls. per ton. Mr. W. J. Butterfield has stated that the benzole recoverable from tar averages 0.2 galls. per ton of coal carbonised, and this figure has been confirmed for London tar by Mr. S. S. Field, formerly of the South Metropolitan Gas Co's. Tar Distillery. From coke oven plants a much higher yield is obtained because washing out the benzole from the gas is commonly practised. By the thorough application of gas washing the yield per ton coal is raised to nearly 2.5 galls. per ton, and the high result of 0.4 galls. given above is probably largely due to inclusion of the high yield from coke oven plants. We have, however, definite data as to production during the period of the war when compulsory " gas stripping " was practised; in 1918 Adam gives the benzole production as 26.4 million galls., and he states that if stripping plant were installed in all gas works, such plant being operated at 66 per cent. recovery (so as to not unduly degrade the gas) the annual production could be increased by 27 million gallons. A reasonable estimate for our " possible " production would appear to be 45 million gallons. But apart altogether from estimates it is certain that we are not obtaining anything like the full output of benzole from the vast quantities of coal carbonised to-day. It is, of course, the ambition of some fuel economists to abolish the use of raw coal and insist on the carbonisation of practically the whole of it, with a view to producing smokeless solid fuels and a great increase in the production of liquid fuels, including motor spirit. By low temperature carbonisation (i.e., temperatures circa 500°C.) the tar yield is some 60 per cent. higher than from high temperature carbonisation. The only independent authoritative tests on a low temperature carbonisation process within the writer's knowledge are those published recently for the Fuel Research Board on the Parker plant at Barugh, Barnsley. The tar yield was 18.62 galls. per ton of coal, from this a yield of 1.09 galls. of a crude first fraction (boiling up to 170°C.) was obtained. After acid refining and again distilling to 170°, 0.756 galls. of a motor spirit per ton of coal was obtained. By oil scrubbing the gas 1.78 galls. of crude product (boiling to 200°C.) was obtained per ton of coal; after acid washing and distilling a refined spirit yield of 1.39 galls. (boiling to 170°C.) resulted. Thus the total acid washed and redistilled spirit amounted to 2.146 galls. per ton. These results hardly bear out the optimistic estimates of motor spirit likely to be obtained from low temperature distillation processes, even allowing that refining losses may be less with large scale operating.

There is considerable promise that the removal of benzene and its homologue from coal and coke oven gas may be improved by absorption methods, using silica gel or the highly absorbent charcoals, such as were used in gas masks, and are used for absorbing gasoline from natural gas. The use of silica gel has been investigated in the laboratory and a large plant inspected in America by the Benzole Research Committee of the National Benzole Association (1st Report). The absorption efficiency was very high (95 per cent.) but the directly recovered benzole was not of good colour. By simple further treatment, involving distillation, the over-all efficiency was 80-82 per cent. The freezing point of the benzole was, however, too high (-7.3°C.) to comply with the English specification (-14°C.).

Another important matter is the degree of refining necessary for the motor benzole fraction of the crude coal tar naphtha. For such purposes as the conversion of benzene into nitro-benzene, the first step in the production of aniline, a fairly close fractionation and a fairly drastic acid treatment has been usual. Hydrocarbons, other than those of the aromatic series, are undesirable for the nitration process, but the presence of paraffin and naphthene hydrocarbons (as in low temperature naphtha) and unsaturated hydrocarbons, are no drawback in a motor benzole, providing the latter are not of so highly unsaturated a character as to produce darkening in colour and the formation of gummy products on keeping. Simpler methods of refining, with consequent material reduction in the refining losses, are, therefore, possible where the product is destined for use as motor fuel. In all probability the use of sulphuric acid will prove unnecessary, as has been demonstrated with petroleum spirits and kerosene, and filtration through calcined bauxite, charcoal or silica gel may be found satisfactory, although the latter has been abandoned for treating the cracked spirit produced by the Cross plant at the Isle of Grain.

It must, of course, be remembered that there are other and highly important markets for benzole besides the motor spirit market and by no means all the benzole will be available for fuel use. Indeed the competition for benzole for other purposes may exercise a very important influence on price. To-day motor benzole is selling retail in London at just over 2/- per gallon, and when collected by the user at one large refinery at 1/9½ per gallon, as against 1/6½ for "combine" No. I. petrol, and a considerable quantity of petrol is being retailed at about 1/3 per gallon, and cracked spirit at the same or a slightly lower figure.

NOTES ON BOOKS.

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SALESMANSHIP. By G. A. J. Hopkins. London: The Louis Cassier Co., Ltd.

A nation of shopkeepers can hardly afford to neglect the science and art of salesmanship, and several praiseworthy attempts have been made in recent years to educate salesmen. For instance, the Pottery and Glass Trades Benevolent Institution have held well-attended courses of lectures, at which salesmen were instructed in the processes of the trades; and they were also taken round factories in order that they might see for themselves the works in actual operation. In another movement, connected with the L.C.C. Central School of Arts and Crafts, groups of salesmen were conducted round the museums, with the idea of familiarising them with beautiful objects and thus educating their tastes, in the hope that they would be eager to persuade their customers to buy the beautiful rather than the inartistic goods. Movements of this sort are to be warmly encouraged: they cannot do any harm, and they may do a very great amount of good.

Mr. Hopkins does not deal with this side of the question. His thesis is rather the personal relations between the commercial traveller and the buyer of his goods. We believe he has proved himself an exceedingly successful salesman, and in this volume he indicates the lines on which he has achieved success. His advice is very sensible—we should have said obvious, but for the recollection of certain commercial travellers whom we have met, and who would do well to mend their methods by studying those advocated by Mr. Hopkins.

GENERAL NOTE.

NEW AIR ROUTE IN THE BELGIAN CONGO.—According to information received by the United States Trade Commissioner at Johannesburg, an air route will soon be inaugurated between Leopoldville and Elizabethville in the Belgian Congo. A special aeroplane designed for use in that region has been built for the Belgian state-aided Aerial Transport Co.; it is equipped with three engines and is designed to eliminate the risk of compulsory descents through engine failures. The machine will be employed in regular services, carrying passengers, mails and goods to and from remote tropical stations. At the present time it takes 45 days to cover the 1,200-mile distance between Leopoldville and Elizabethville, but by the proposed new service, the journey will be covered in two days. The plans of the company arrange for the machines to be in communication with aerodromes during the whole flight, by means of wireless telephony.

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PROCEEDINGS OF THE SOCIETY.

HOWARD LECTURES.

MOTOR FUELS.

By J. S. S. Brame, F.I.C., F.C.S.,

Professor of Chemistry, Royal Naval College, Greenwich. Past President, Institution of Petroleum Technologists.

LECTURE II.—*Delivered 27th April, 1925.*

POWER ALCOHOL.

For several years past the possibilities of alcohol as a fuel for internal combustion engines have been under consideration. It is recognised that alcohol is, so far, the only true artificial fuel—one which can be manufactured without having recourse to raw materials which are themselves natural fuels. It is admitted that supplies of petroleum and of coal and like minerals, which to-day furnish all the liquid fuels suitable for use in internal combustion engines, are not inexhaustible; that some day it seems certain fuel will have to be manufactured from other raw material. Alcohol, in the light of to-day's knowledge, is the only liquid which we actually know how to produce independently in quantities which are in any way capable of contributing materially to requirements.

That alcohol, either alone, or better in admixture with other combustible liquids, is a practical fuel, with certain definite advantages, has been proved not only by experimental work but in the greater test of actual commercial use.

That its great possibilities and the necessity for obtaining all possible information on its use, production and cost are so recognised officially was evidenced by the appointment in 1918 by Mr. Walter Long (afterwards Lord Long) of a Departmental Committee to consider and report upon—

1. Sources of supply, methods of manufacture and cost.

2. Suitability, either alone, or in admixture, for use as a fuel for internal-combustion engines, and possible modifications for existing types of engines.
3. Questions of denaturing and alterations in Excise regulations.

As the outcome of this Committee's work Sir Frederick Nathan was appointed Power Alcohol Investigation Officer, and already three most valuable reports have been issued under the ægis of the Fuel Research Board.

Credit must also be given to the far sighted policy of the Department of Scientific and Industrial Research, the Royal Automobile Club and Commercial Motor Users' Association for providing considerable sums of money for research work on the practical side of the use of alcohol as fuel. Few more valuable reports have been produced than that of the Empire Motor Fuels Committee, issued last year under the auspices of the Institution of Automobile Engineers, which contains the results of these researches.

But, as very tritely expressed by S. W. Sparrow, of the U.S. Bureau of Standards when discussing the motor fuel problem—to burn a gallon of alcohol one thing is essential—a gallon of alcohol!

Alcohol to-day can be accepted as a fuel of proved merit; the only question for debate is whether it can be produced, or is likely to be produced in the near future, in quantities sufficient and at a price which will enable it to compete with success against its present rivals—petrol and benzole. Restrictions on production, handling and distribution have been largely removed.

The questions of possible yields from different sources and costs per gallon from various raw materials have been very freely discussed in many publications and memoirs. An excellent contribution to the known facts and reasoned criticism of the whole subject has been made by Mr. G. W. Monier-Williams in his treatise on "Power Alcohol."

Briefly the conclusions which have been reached are that raw material of high food value (grain) is too valuable as food, that tubers and roots are more promising but the cost of growing and handling makes the cost of the alcohol high. The position was summarised as follows in the first Report on Fuel for Motor Transport (Fuel Research Board) :—

> "Considerations indicate that it is almost a necessity to use a waste material, or a natural product of little or no value apart from its possible utilisation as a source of alcohol."
>
> "In general, the production of alcohol in any considerable quantity from vegetable material grown in the United Kingdom is not economically possible."

In the second Report (1921) the possibilities of economical production in the British Dominions and Colonies are considered, the general conclusion being that :—

> "It is unlikely that alcohol could be produced (by the methods considered in the Report) in excess of local needs, and at a price, when

freight to seaboard and to this country is included, at which it would find a market here."

There are, however, certain other sources which have already been utilised for commercial production or investigated. These include waste starchy material found in straw, and cellulosic material. Waste sulphite liquor from paper pulp mills has been successfully used—Canada, it is estimated, could produce some 5 million gallons per annum from this source. Wood waste (including sawdust) has been utilised somewhat extensively, but, according to the Second Memorandum on Fuel for Motor Transport (1921) "can hardly be said to be commercially successful as yet."

The production possible from the waste molasses from sugar refining throughout the Empire—if the whole were available for power alcohol production—has been estimated as not exceeding 15 million gallons (2nd Memo. F.R.Bd.)—a very small contribution to the requirements of motor fuel in the Empire, excluding the mother country.

The most promising source of cheap raw material lies in the prolific vegetation of tropical countries, which would furnish practically inexhaustible quantities of alcohol. Here in Nature's great laboratories the heat energy of the sun could be transformed into potential fuel in a few weeks or months. But the problem is are the resources of man's laboratories equal to the release of this fuel in a form suitable for use in internal combustion engines, in other words, as alcohol? The process must be simple and economical and no such process has so far been devised.

Even with the invention of such a process there are many subsidiary problems which would arise. The centres of manufacture would have to be located at the centre of production of the raw material, such low grade material would not bear handling and transport costs. Fuel for distillation and sufficiently cool water for satisfactory condensation would involve other problems. The transport of the finished alcohol would, as Monier-Williams points out, again present some difficulty. Taking the yields from a fair sized plant as one million gallons per annum—say 3,600 tons—a small tank steamer would carry at least twice or three times this quantity and in all probability collection of the product would only be economically possible once or perhaps twice yearly. This implies considerable storage accommodation on the spot and in tropical countries some considerable loss by evaporation.

Synthetic methods for manufacturing alcohol have been worked on a fairly extensive scale, but up to the present synthetic alcohol does not appear able to compete in price with fermentation alcohol.

It is necessary to consider alcohol as fuel in relation to conditions to-day and in the future, as far as one can foresee the position of supplies of petrol. So far there is no indication that the petroleum industry is going to fail for many years to come to meet the ever growing demands for petrol. Monier-Williams, writing at a time when petrol was two-shillings and sixpence per gallon (without the duty at that time charged) expressed the view that "even assuming the raw material to cost nothing at all, it would be barely possible for alcohol to compete commercially with petrol provided that the supplies of the latter were adequate and the price were reduced to the lowest possible level." To-day large quantities of good petrol are being retailed in this country at half the price mentioned above.

The position of alcohol as a fuel to-day, and one may safely add for a number of years to come, is that it is not possible to produce it at such a price that it can replace even an appreciable fraction of the petroleum product. By artificially fostering the production by bounties on alcohol production and import taxes on petrol it might be possible to create a competition, but no such action is at all likely to receive serious consideration from a British Government. Alcohol may truly be described as the young fuel with an undoubted future. It will come into its own only when its elders—petrol and benzole—are becoming exhausted. Physiologically we recognise alcohol as a good stimulant and reviver—in its day it will play a similar role in fuel economy; it is not difficult to foresee a day when alcohol and derivitives of alcohol may be almost the sole liquid fuels available to man. Before that period is reached alcohol will certainly become a supplementary fuel to petrol and benzole, and fuel mixtures of these three, or more expecially of alcohol and benzole, all of proved practical value, are likely to find wide application as soon as the production of petrol suffers serious diminution and its price becomes consequently enhanced. Alcohol, moreover, has certain advantages as a component of fuel mixtures which will more than compensate in them for an appreciably higher price of this ingredient.

One of the most important questions relating to the use of alcohol for power purposes is that of denaturing—rendering the product permanently unfit for human consumption. Sir Charles Bedford in a paper before this Society in 1921 (J. R.S.A. 1921, **69**, 478) dealt comprehensively with this undoubtedly difficult problem. At first sight it appears a fairly simple matter to render alcohol non-potable, but actually it cannot be said that a denaturant has yet been found which properly fulfils all the many requirements.

These have been set out by the Board of Customs and Excise and may be summarised as:—

Complete solubility in alcohol, benzole and petrol and mixtures of these.
Not easily removable.
Having a nauseous taste but not actively poisonous.
Stable, and not acting corrosively on metals.
Procurable in sufficient quantity and the cost not excessive or liable to wide fluctuations.

In general crude wood naphtha ("wood spirit") has been the most widely used denaturant and 10 per cent. of this rather complex product added to the alcohol of fermentation constituted the old methylated spirit. This alone was not found to prevent consumption entirely and later the excise regulations demanded the inclusion of a small quantity of mineral (coal tar) naphtha, (" mineralised methylated spirit.") a distinctive colour being given by a small quantity of methyl violet. Pyridine and bone oil (which contains pyridine) have been used in other countries in lieu of mineral naphtha, and many other substances have been proposed. So important is the question of denaturation that a special Sub-Committee of the Empire Motor Fuels Committee was set up.

One very important matter, as affecting importation of power alcohol between different countries in the Empire is the different methods of denaturing which are employed, and which would prevent entry of spirit because it did not comply with the system in vogue in the importing country. It is most desirable that a recognised denaturant should be sanctioned by agreement throughout the Empire.

The increased price and drawbacks inherent to the use of crude wood naphtha led an Interdepartmental Committee to recommend in 1919 a reduction in the quantity employed in alcohol for power purposes, if petrol, benzole or other approved substances were employed in its stead. The Power Methylated Spirits Regulations (1921) stated that such spirit shall consist of alcohol of a strength not less than 66 per cent. over proof, to which has been added not less than 2.5 per cent. of wood naphtha, 0.5 per cent of crude pyridine, and 5 per cent. of benzole. This must be coloured by the addition to every 1,000 gallons of 0.75 ounces of Eosin and 0.25 ounces of " Spirit Red 3." Before removal from bond not less than 25 per cent. of petrol, benzole or "other approved substance " must be added under Excise supervision, unless the power spirit already contains not less than 25 per cent. of denatured ether. When so mixed the mixture may be handled and distributed without further restriction.

The production of synthetic methyl alcohol is of importance in relation to power alcohol. Processes are actually being worken successfully in France and Germany for its manufacture from water gas and hydrogen, combination being effected in the desired way ($CO + 2H_2 = CH_3OH$) by the aid of a catalyst at pressures of 150-200 atmospheres. The Badische plant at Merseburg (Germany) was stated to be producing, in 1923, 10 to 20 tons of methyl alcohol per day.

Corrosion troubles, which have frequently occurred with methylated alcohol fuels, appear to be due to impurities in the wood naphtha (esters, which by hydrolysis produce acids). The use of synthetic methyl alcohol would eliminate such corrosion of tanks, pipes etc.

FIRE RISKS WITH MOTOR FUELS.

The danger of explosion and fire with petrol is so well recognised that Regulations under the Petroleum Acts, and Bye-Laws by Local Authorities had of necessity to be passed, to control the safe transport, storage and handling of inflammable spirits. It is a striking testimony to the able drafting of the

Regulations that accidents are almost unknown in this country. With the very wide distribution of motor spirit amongst a population which can have only a general knowledge of the inflammable character of motor spirit it is really surprising that very few accidents have arisen.

Explosion and fire risks are dependent upon the degree of volatility of the fuels, the minimum quantity of vapour necessary to give an explosive mixture and the ignition point of the respective fuel-air mixtures.

In considering these risks the flash point of the fuel is as useful as actual vapour pressure determinations of the relative volatility of the three most commonly used fuels. Naturally, as all the commercial fuels are variable in composition, considerable variation in their flash points is found. From the work of J. H. Coste and Ormandy and Craven the following flash points are taken.

Petrol —11 to —30°C.
Benzene —12°C.
Toluene +9 to 10°.
Alcohol (95%) +15° to 18°C.
Methyl alcohol +10°.
Power alcohol +1° (5% benzol)

A motor benzole was found to flash readily in the writer's laboratory at —9°C.

The explosive limits for the three fuels—taking in each case the extreme values found by different observers under any conditions of experiment—are :—

	Min.	Max.
Petrols	1.5	6 per cent. (vapour)
Benzene	1.4	7.5 ,, ,, ,,
Ethyl alcohol ..	3.56	18.0 ,, ,, ,,
Methyl alcohol ..	7.05	36.5 ,, ,, ,,

The minimum quantity is, of course, the approximate measure of the concentration of vapour with air when dangerous conditions exist. Petrol and benzole are approximately the same, but the higher volatility of petrol determines the minimum quantity of vapour being reached more readily, the risk, therefore, being undoubtedly greater with petrol than with benzole. Alcohol is much safer than either of the others, even with the 5 per cent. benzole present in power spirit, for three reasons, the lower degree of volatility and the considerably higher minimum for the formation of an explosive mixture. The third reason is important : the heavy creeping nature of petrol vapour, and to a slightly less extent of benzole vapour. Approximately the vapour from petrol is 3 times as dense as air, benzene, 2.5 times, alcohol 1.5 times. Formation of an inflammable mixture at floor levels, in pits, etc., is much more probable with the heavier vapours, the diffusion upwards being relatively slow, and it is well known that ignition of petrol vapour and benzole vapour has not infrequently carried a flash back over considerable distances to containers, stills, etc.

The ignition temperature of fuel/air mixtures presents some difficulty for considerable variation is found in the data for the same substances, variation arising from the method of determination employed. By totally different methods Harold Moore and Ricardo obtained the following ignition temperatures for petrol in air :—360-390°C. (Moore); 353-367°C. (Ricardo). For benzene/air mixtures Ricardo obtained 419°C. For ethyl alcohol 518°C. (Moore); 514°C. (Ricardo).

Again, alcohol has a very marked advantage over both benzole and petrol, but, of course, with each of the fuels the ignition temperature of the fuel/air mixture is well below a flame or electric spark temperature. It is very necessary therefore, that no risks be taken with naked lights and all electric fuses and switches should be either outside a garage or store, or enclosed in gas tight cases. A point to which attention may well be drawn is the necessity for care in the condition of wandering leads on portable electric lamps in garages. A mechanically produced spark has also given rise to explosion.

A risk of ignition which is not sufficiently known is that arising from electric charges being generated when petrol flows through rubber pipes and Richter many years ago showed that "benzoline" by friction with silk or wool produced a charge sufficient under favourable conditions to spark and ignite the vapours.

Some very remarkable instances of fires resulting from static electrical charges developed by flowing petrol might be quoted. Several fires have for example occurred when filling tank wagons through rubber hose. Any waggon should be properly earthed—it is quite common to trail a chain on the ground. Again a metal nozzle should similarly be earthed—the use of armoured rubber hose, which is usual, ensures this. A further obvious precaution is to ensure good metallic contact between a filling nozzle and a tank which is being filled. If the tyres of an ordinary car are dry the car is very effectively insulated. Petrol flowing through a rubber hose and a spout not in contact with the petrol tank may develop dangerous conditions. It is important to ensure metallic connection between the filling spout and the tank.

One final point in connection with the safety of others than the users of petrol is the danger of allowing petrol, or similar fuels, to run down drains into sewers. Regulations prohibit such a dangerous practice but it is obviously impossible in private garages to ensure the observance of these regulations. It must be left to the individual to avoid this very dangerous proceeding.

PHYSICAL PROPERTIES OF MOTOR FUELS.

Both the physical properties and the chemical constitution of motor spirits have important bearings on their qualities as fuels.

Specific gravity is to-day a totally misleading property, although the fallacy of regarding it as a criterion of value still persists in many quarters. When practically all petrol was essentially of the paraffin hydrocarbon type, specific gravity was a fair criterion of quality, since the distillation range and the amount of highly volatile hydrocarbons present were approximately shown by low, medium or high gravity. To-day, when many petrols are of the naphthenic type, and others contain a fairly high proportion of aromatic hydrocarbons, such spirits may have just as high a degree of volatility yet be of high gravity as other spirits of much lower gravity.

This point is well illustrated by the following comparison of three individual hydrocarbons of the three principal types found in petrols.

	PARAFFIN. (Heptane)	NAPHTHENE. (Hexa-methylene)	AROMATIC. (Benzene)
Boiling point	83-84°C.	81°C.	80.5°C.
Sp. gravity	0.70	0.81	0.88

BOILING RANGE, or Distillation Range is certainly the best physical method of valuation and therefore is found in all standard specifications. These generally lay down temperatures at which definite percentages should distil under standard conditions, and the final boiling point. Thus the British Engineering Standards Association specification for "Motor Spirit" demands an initial boiling point not above 55°C.; that 20 per cent. shall distil below 105°C., and the final boiling point shall not exceed 225°C. This is practically the same as the Standard American specification.

Certainly all No. 1 Grade Motor Spirits marketed in this country to-day are of much higher grade than the specification and numerous distillation tests of samples of the various well-known brands show remarkable uniformity in respect to the distillation results. Ease of starting from cold is generally regarded as indicated by the temperature at which 20 per cent. distils, and the following are average figures for motor spirits of to-day.

	20% distils below.
Aviation spirit	70-80°C.
No. 1 Petrol	85-90°.
Motor Benzole	85°.
Benzole/Petrol mixture	85°.

For use under considerably reduced pressure, as in aviation, too high a volatility is often undesirable. Belgian aviation spirit actually had the lowest boiling constituents removed.

Sparrow states that in experiments made in the U.S. Altitude Chamber, high volatility led to vaporisation in the fuel supply pipes, so upsetting carburation, and finally stopping the engine, and that the rapid evaporation of a fuel of high latent heat of vaporisation led to such lowering of temperature that a fine snow was formed from the damp air and the engine ran very erratically, a trouble overcome by sufficient warming.

The maximum boiling range, or proportion of the fuel distilling over above a certain arbitrary temperature involves some important considerations. It is very desirable to make this "end point" as high as practically possible because it means an increased yield of petrol from a given crude oil.

The limitation to this end point is determined chiefly by the possibility of completely burning the fuel. If the proportion of high boiling constituents is fairly high, owing to the failure of these portions to vaporise, combustion is incomplete, the heavier portions are absorbed by the lubricating oil and dilution of the oil in the crank case occurs.

The British Standard Specification for petrol at present gives a final boiling point of 225°C., but the average found is about 180°C. for No. 1 Petrol in this country, and for Aviation Spirit about 140°C. In the United States the ordinary motor gasoline has an end point of about 220°C.

These figures are reflected in the amount of crank case dilution. Nickinson found for a fleet of motor buses 2.5 per cent. in summer and 6.5 per cent. in winter. In the U.S. some recent figures indicated from 25-30 per cent.

VISCOSITY.

This has an important influence in determining the bore of a carburettor jet necessary to pass a given volume of liquid in unit time; thus at an average temperature such as might be expected under the bonnet of a car (30°C.) petrol and benzole have the same viscosity, whilst the viscosity of alcohol is such that a jet of the same bore would pass a little less than half the volume.

A further important point is the change of viscosity of the fuels with change of temperature. On a cold day (engine cold) the volume of fuel passed is the minimum but the weight of air the maximum—that is, the mixture is weak. On a hot day, or when the engine is hot, the volume of fuel passed is appreciably greater, but the weight of air is much less—that is, the mixture is much stronger. This is just the opposite to what is desired, a rich mixture being required for starting with a cold engine, but when the engine is hot the best economy is obtained with a moderately weak mixture, and provision is of course made for adjusting the mixture strength.

Moreover the change of viscosity with rise of temperature is very different with the three types of fuel, and this must appreciably influence the functioning of carburettors. From results obtained by Sorel for the weight of liquid passed by a standard capillary tube the following figures have been selected, water at 15° C. being taken as 100.

	Petrol.	Benzole.	Alcohol.
At 0°C.	100	60	22
At 30°C.	116	116	45

Petrol shows a comparatively small increase but with benzole and alcohol almost double the quantity of liquid was passed within a range of temperature likely to be met with in practice.

EXPLOSIVE RANGE.

For an explosion to occur in a closed space, such as the cylinder of an engine, the fuel/air mixture must fall within certain limits of composition; a minimum of vapour (lower limit) must be reached, a maximum (upper limit) must not be exceeded. In the case of petrol and benzole the range is comparatively narrow, in the case of alcohol it is much wider. Adjustment of mixture strength to suit conditions is, therefore, strictly limited with the former fuels, but much wider scope is afforded with alcohol.

Many conditions affect the lower and upper limits, such as whether combustion proceeds upwards, downwards or horizontally; further, temperature and pressure have their influence. Again in a cylinder residual exhaust gases are present, whereas determinations of the range are made with a pure fuel/air mixture. The average explosive range for the three types of fuel are shown in Fig. 2.

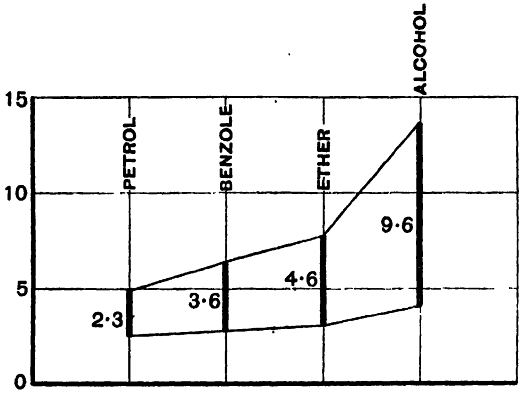

FIG. 2. Explosive Range—Electrical Ignition.

In practice the mixture range is even more restricted. It has been found that the weakest mixture capable of operating a single cylinder engine was 80 per cent. of the theoretical mixture for complete combustion. With a purely paraffin petrol this would agree with about 3 per cent. by volume of vapour, which is considerably higher than the lower explosive limit for paraffin hydrocarbons.

CALORIFIC VALUE.

There is a very considerable difference in the heat value of petrol, benzole and alcohol; variations naturally are found for each because of differences of composition in commercial grades, but the following are average "gross" figures:—petrols, 20,000; benzole, 17,700; alcohol, 11,200 B.Th.U. per lb. Motor fuels are, however, bought by the gallon and obviously an advantage lies with those fuels of high specific gravity, as the following figures for petrols show. (Ricardo.)

	B.Th.U. (net).	
Sp. gr.	Per lb.	Per gallon.
0.704	19,250	135,500
0.727	19,120	137,000
0.760	18,890	143,500

From the point of view of performance in the engine, however, the calorific value of the mixture admitted to the cylinder is of primary importance and this is dependent upon the quantity of air requisite for the theoretically complete combustion of the fuel, a quantity readily calculated when the composition of the fuel is known.

MANUFACTURING INDUSTRIES OF ARGENTINA.

Most of the factories in Argentina producing manufactured goods are situated in or around Buenos Aires, which provides a consuming population of nearly 2,000,000. Their total output in quantity, quality, and variety has shown a notable expansion. The initial stimulus was, of course, given by the war, but various circumstances have combined to strengthen their position, such as the increased cost of production in other countries, the hesitancy of merchants to order stocks ahead of the season from abroad in view of fluctuating prices, variations in exchange and uncertainty in deliveries, the relatively lower extent to which wages and taxes have increased in Argentina, and particularly, the increased protection for which all industries, prosperous or nascent, perpetually clamour and eventually receive. While no deliberately framed policy of protection has yet passed into law, the Commercial Secretary to H.M. Legation at Buenos Aires, points out in his recent annual report that the importation of many ranges of goods is precluded by high duties introduced fortuitously, such as the imposition of special protective rates of duty in committee, on certain classes of goods, and in addition an all-round increase of the tariff superimposed by Congress. This has occurred in the case of footwear, manufactures of rubber and lead, cement, confectionery, cigarettes, ready-made clothing and other articles.

Importers of goods which go straight to the consumer find local competition serious, but on examination it would appear that the growth of local industries offers more obstacles to German and continental exports than to those of the United Kingdom and United States. The leading British exports are restricted more by competition from the continent of Europe and from the United States than by the combined effect of the Argentine tariff and local competition. On the other hand, this combination has to a large extent shut out British groceries and provisions, confectionery, beverages, boots and shoes, brassware, leather goods, hats, brushware, soaps, wearing apparel and bedsteads, the last two items being examples of the substituted importation of the material, piece-goods and tubing, for the finished article.

The increased production of cotton has led to the installation of ginning machines, mostly American, and a few weaving factories are installing spinning machinery which has already led to an agitation for increased duties on yarns. The woollen industry with the raw material at hand is fairly extensive, producing heavy cashmeres for men's and women's suitings and the uniform cloths of the army, navy and police. Knitted hosiery and underwear from imported yarns are the product of another group of factories; local production of wrapping paper and of paper and cardboard containers supplies most of the demand. Structural steelwork is produced behind a protective duty. The production of all classes of common and medium glassware and bottles has replaced large German and Belgian exports of these articles, but no china and earthenware is made. Furniture making has increased greatly compared with before the war, but in design and quality cannot bear comparison with European models, which the public are only forced to forego by high prices, freights and duties.

Although Argentine products are now much more known than formerly to the consumer the practice is still widespread of presenting them as imitations of imported goods, even to the use of foreign languages. It is expected that the coming into force of the Merchandise Marks Act, requiring the equivalent of " made in Argentina" to be inscribed on locally made goods, together with the comprehensive industrial exhibition held in December, 1924, will mark the diminution of this practice, and also the motive for it.

PEAT RESOURCES OF POLAND.

The peat resources of Poland have not yet been properly explored and valued, although estimates of a very general kind made before the war, as well as data collected in some provinces since the war (according to a report by the United States Consul at Warsaw), suggest that the total area of Polish peat fields amounts to 2,830,000 hectares (9,200 square miles), or 6.15 per cent. of the total area of the country.

The peat fields consist mainly of low bogs, and an investigation showed that the peat is of medium quality with a probable mean heating value of 3,000 calories per kilo (5,400 B. T. units per pound) when dried to 25 per cent. moisture. One kilo of peat can be taken as equivalent to one-half kilo of average Polish coal, which has a heating value of 6,000 calories. The estimated total of peat resources, therefore, represents an equivalent of 1,500,000,000 metric tons of coal.

Peat bogs are distributed over the entire country, but are particularly numerous in the eastern provinces, and are almost exclusively worked for the production of household fuel in regions poor in wood and deprived of convenient communications with the Polish coal basin. In view of the scarcity of other fuels, the consumption of peat showed an increase during the war and in the years immediately thereafter. It is again on the decline, however, and the lack of statistical data renders it impossible to estimate even approximately the actual consumption.

Conditions are favourable for the establishment of electric stations burning peat in the eastern provinces, which are situated at a great distance from the coal basin and possess large peat fields. A high content of nitrogen, often exceeding 2 per cent. of the dry matters, points to the advantages of peat gasification with recovery of nitrogen compounds.

GENERAL NOTE.

FOX FARMING.—Fox farms have been started in Scotland, Hertfordshire, and elsewhere, and, according to *United Empire*, the industry appears to hold out considerable promise for the investor prepared to devote time and attention to it. With the gradual increase in the numbers of breeding stock in this country, it is no longer necessary to purchase pairs in Canada and incur the risk and expense of their transport across the sea ; while the success in a recent sale when a pelt from a British farm topped the sales of the Hudson's Bay Company in London, augurs well for the future possibilities of the industry. A fair price for a pair of good foxes appears to be about £250 ; the cost of feeding is about £10 per pair per annum ; and the construction cost of a ranch of ten pens is about £400. The price of the pelts varies considerably, ranging from £15 to over £100.

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PROCEEDINGS OF THE SOCIETY.

HOWARD LECTURES.

MOTOR FUELS.

By J. S. S. Brame, F.I.C., F.C.S.,
Professor of Chemistry, Royal Naval College, Greenwich. Past President, Institution of Petroleum Technologists.

Lecture III.—*Delivered 4th May*, 1925.

The Fuel/Air Mixture.

Some small variation in the quantity of air theoretically required is found for different petrols, benzoles, etc., but approximate figures are as follows :—

	Lbs.	Cu. ft. at 60°F.
Petrols	15	197
Benzoles	13.3	174
Alcohol	8.5	112

On the basis of these figures and those for the net calorific value of the three fuels, the approximate calorific values per cu.ft. of mixture (at 60°F.) are calculated as given below, together with figures given by Ricardo expressing in terms of ft.-lb. of energy the corresponding facts.

	Net calorific value of mixture at 60°F.	Heat of combustion per cu. in. of mixture.
Petrol/air	95 cals.	46 ft-lbs.
Benzole/air	97 ,,	47 ,,
Alcohol/air	87.5 ,,	44 ,,

It is to be expected, therefore, that little difference will be found in the behaviour of fuels of each class in practice, and Ricardo's experiments indicated that for volatile hydrocarbon fuels the power output was substantially the same. With alcohol fuels, because mainly of evaporation partly taking place during the compression stroke and the higher latent heat of vaporisation, the temperature of the cycle is lower and the power output thereby somewhat increased. The thermal efficiency obtained with ethyl alcohol at all compression ratios was found to be about 2.5 per cent. higher than for hydrocarbon fuels. The consumption of fuel, however, will be different for each, particularly for alcohol; in a given engine for a given power it will be from 1.5 to 2 times greater than for petrol.

The maximum power output is found usually with mixtures slightly richer than the theoretical, whilst the maximum thermal efficiency (indicating higher fuel economy) is found with mixtures having a fuel/air ration of about 1/17. In general,carburettors are adjusted to give a mixture richer than the theoretical, certain advantages being thereby gained, (easier cold starting, better acceleration and higher power output) but at the expense of economy. Over-richness, however, leads to incomplete combustion, carbon monoxide being formed, entailing very considerable losses of heat units, thus 4.5 per cent. of carbon monoxide in the exhaust gases means a 20 per cent. waste of fuel.

Whilst the greatest fuel economy is obtained with weaker mixtures, starting from cold cannot be made with any mixture much below the theoretical; again weak mixtures are slow burning and combustion may not be completed before the end of the stroke, and there is the further difficulty with multi-cylinder engines of distribution of a uniform mixture to every cylinder, one or more more may not always fill with a mixture of sufficient richness to fire properly, and failure in this will lead to uneven running.

The effect of mixture strength on power output and thermal efficiency is well illustrated by the work of Fieldner and Jones, in the Pittsburg Experimental Station of the U.S. Bureau of Mines. Some selected curves are given in Fig. 3.

Employing the usual methods of exhaust gas analysis, both in bench tests on engines, and with portable analysis apparatus on cars on the road under all conditions, some valuable data has been obtained. With petrol, the theoretical carbon dioxide in the exhaust should be 14-15 per cent.; in a very exhaustive series of tests in the United States it was found to range, with few exceptions, between 7-12 per cent., and the average carbon monoxide from 6-7 per cent., indicating about 30 per cent. waste of fuel. Very great improvement was obtained by adjusting the carburettors on the gas analysis, good result being reported for a carbon dioxide content of 13.7 to 14.7 per cent.

From the analysis of the exhaust gases from a single cylinder engine W. Watson found the maximum of carbon dioxide at the following air ratios—petrol, 15 lbs.; benzole, 13.8 lbs.; alcohol, 8.2 lbs.

The production of carbon monoxide may, under some circumstances, become a danger, and several fatal accidents have arisen in garages. The atmosphere may become so charged with this odourless gas that, without warning, a person may drop unconscious, and, if assistance is not rendered, may succumb. Absorption by the blood is slow and there is, therefore, some difficulty in ascer-

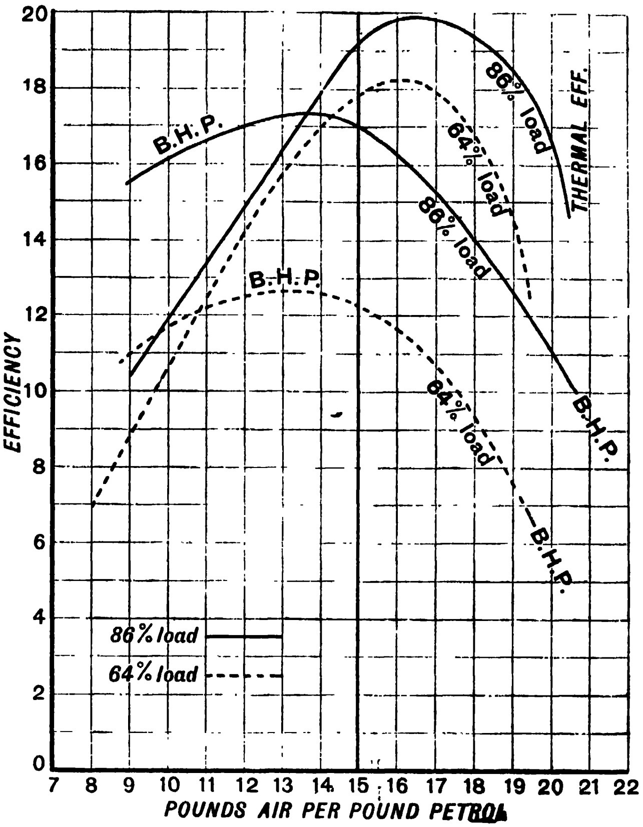

FIG. 3.—Thermal and mechanical efficiency with petrol/air mixtures richer and poorer than theoretical (15 lbs. air per lb. (petrol).

taining the exact danger concentrations, but 0.2 per cent. is regarded as "dangerous," and 0.4 per cent. will produce unconsciousness and may be fatal if breathed for one hour.

W. P. Yant (U.S. Bureau of Mines) states that "The average automobile will create an atmosphere containing 0.5 to 0.7 per cent. of carbon monoxide in 8 to 10 minutes in a closed garage of 1,500 c.ft. capacity.

COMPOSITION OF FUELS AND EFFICIENCY.

On theoretical grounds the thermal and mechanical efficiency of an internal combustion engine should be greater the higher the degree of compression of the fuel/air mixture, and in practice this is well recognised to be the case.

Ricardo, with the variable compression engine, described later, demonstrated for example that with a particular fuel the Indicated Thermal Efficiency of 27.7 per cent. was obtained with a compression ratio of 4-1, and 37.5 per cent. with the ratio increased to 7-1; a gain of 36 per cent.

As the compression of the fuel/air mixture rapidly raises the temperature of the charge, it follows that if the compression of the mixture is sufficiently high the charge will pre-ignite. The liability to pre-ignition would appear therefore, to be directly related to the ignition point of the fuel/air mixtures. By adiabatic compression Ricardo obtained the following ignition temperatures petrols 353-367° ; benzene, 419° ; toluene, 422° ; ethyl alcohol, 514°C.

Another phenomenon, *detonation*, usually takes place before pre-ignition, giving rise to the " pinking," known to most motorists, and Ricardo has shown that persistent pinking often gives rise to true pre-ignition. Detonation is due to the extremely rapid explosion of the part of the charge left after the more or less progressively rapid combustion of the first portions. No really satisfactory explanation of the phenomena has been given. Ricardo, as the result of experiments on the effect of diluting the mixture with inert gases, was led to discard the earlier views that detonation was a function of temperature and pressure of *compression*, but appears to be a function of the temperature, and pressure of *combustion*. Tizard regards it as a function of flame temperature.

There does not appear to be any direct connection between the ignition temperature of the mixture and its tendency to detonate. Thus Ricardo found that carbon di-sulphide, with the low ignition point (with air) of 275°C., would stand compression to a ratio of 5.15/1, whilst an aromatic free petrol with an ignition point (with air) of 353°C. gave detonation with a compression ratio of 4.85/1.

The reason for this anomaly may possibly be the rate at which the initial combustion reaction speeds up to the point of detonation ; and this appears to increase rapidly with rise of temperature. A parallel is perhaps to be found with explosives. A large mass of guncotton, for example, will burn rapidly when ignited, the combustion speeds up and finally the point of detonation is reached. The powerful effect of fulminate of mercury in setting up detonation in high explosives is not due to its power, or to its rate of detonation, which is slow compared to guncotton or nitroglycerine , but to the rapid increase in the velocity of explosion from the moment of ignition until the true detonation wave is developed. The initial rate of explosion of mercury fulminate is stated to be 10 metres per second, but it reaches its " normal " rate of 4,000 meters per second in one three-thousandth of a second.

Physical conditions will largely influence the tendency to detonate. Thus the distance the flame has to travel ; this being largely determined by the size and shape of the combustion space, and the position of the firing plugs. The turbulence in the mixture also is a big factor, good turbulence reducing the tendency to detonation ; turbulence will be greatly influenced by the position of the inlet ports and by the piston speed. Hence with reduced speed on hills the tendency to knock is increased.

Further the tendency to detonate will be greatest with fast burning mixtures;

weak mixtures and over-rich mixtures being less liable to give detonation because of their slower rate of combustion.

Certainly, however, one of the most important lines of research on the internal combustion engine has been the work of H. R. Ricardo, on the effect which the composition of the fuel has on the liability to detonation; because it has pointed the way to increased efficiencies by suitable choice of fuels, or blending of fuels, and has led to the discovery of compounds with remarkable anti-detonating characters.

Using an ingeniously constructed engine which allowed compression to be varied between the ratios 3.7:1 and 8:1 whilst running at full power and without alteration of any other conditions, Ricardo was able to study the combustion characteristics of the principal components of motor fuels.

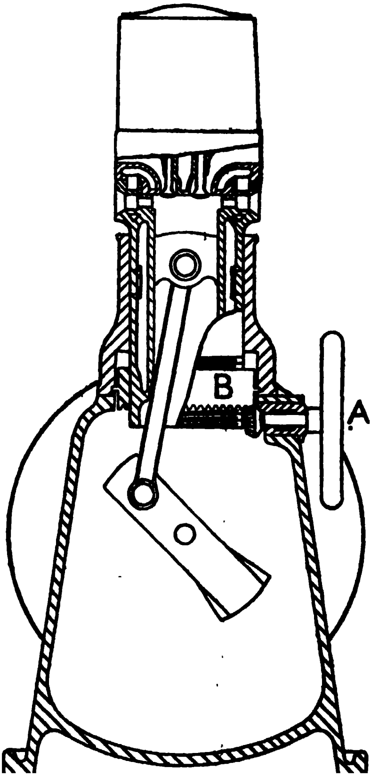

FIG. 4.—Ricardo Variable Compression Engine.

A diagrammatic section of the engine is shown in Fig. 4. The compression ratio was varied by raising or lowering the whole cylinder, including also the carburettor, cam-shaft and valve gear, by means of the handwheel (A) shown on the right of the illustration. Rotating this wheel rotated the collar (B) working in a groove. This collar, working on a thread on the outer wall of the cylinder, raised or lowered the whole cylinder and its adjuncts. A locking device prevented movement when the desired compression had been obtained.

It was demonstrated that the efficiency of all hydrocarbon fuels was the same at the same compression ratio, provided the compression was low enough to avoid detonation under any circumstances, and the power output was also in agreement at the same compressions to within 2 per cent. Alcohol formed an exception, chiefly owing to its high latent heat of vaporisation (nearly 3 times that of petrol) giving greater cooling of the charge, so increasing the volumetric efficiency and consequently the power.

	Latent Heat of Evaporation (Calories per gram).	Fall in Temperature of Mixture due to Latent Heat (Degrees C.).
Hexane	86.6	21.0°
Benzene	95.5	26.0°
Ethyl Alcohol	220.5	83.0°
Methyl Alcohol	284.4	140.0°

If it is possible to increase the compression without producing detonation or pre-ignition then the fuel may be more economically employed. Herein lies the great value of Ricardo's work, for he has been able to establish the highest useful compression ratio for different types of hydrocarbons and alcohol and mixtures of these.

The Highest Useful Compression Ratio (H.U.C.R.) is not the highest compression the fuel/air mixture will bear under any conditions, but the highest it is desirable to employ in practice.

The actual compression at which detonation becomes serious varies somewhat with different mixture strengths and with the ignition timing.

The following table summarises Ricardo's results for the different types of motor fuels.

	Highest Useful Compression Ratio.	Corresponding thermal efficiency.	Minimum consumption at H.U.C.R. Pints per B.H.P.
Petrols	4.55/1 to 6.0/1	30.2 to 34.9	0.402 to 0.484
Benzene (98%)	6.9/1	37.2	0.355
Alcohol (98%)	7.5/1*	40.4	0.533
Methylated spirit	6.5/1*	38.5	0.609

*Detonation not actually reached.

The examination of different hydrocarbons of the same class (some of approximate purity only), of hydrocarbons of different series and alcohols, enabled the order of liability to detonation to be stated as follows—paraffins, cycloparaffins (naphthene hydrocarbons), aromatic hydrocarbons, alcohol.

It was found, moreover, that in mixtures the liability to detonation was generally a straight line function of the proportions of the different classes of hydrocarbons present. Ricardo gave the results for a series of petrols containing various proportions of paraffins, naphthenes and aromatic hydrocarbons in Table III.

TABLE III.

Composition of Petrols in Relation to Compression and Consumption. (Ricardo.)

INDEX NO.	Approximate Composition.			Highest useful Compression Ratio.	Temperature at H.U.C.R. °C.	Consumption at H.U.C.R. per B.H.P. hour.	
	Paraffins	Naphthenes	Aromatics			Lbs.	Pints
7	26	35	39	6.0	430	0.393	0.402
8	10	85	5	5.9	428	0.389	0.405
1	62	23	15	5.7	422	0.393	0.435
6	38	47	15	5.35	410	0.407	0.428
3	68	20	12	4.7	387	0.435	0.484
X	63	35	1.7	4.85	392	0.422	0.471

X.—A petrol from which aromatic hydrocarbons had been removed.

The analytical results for the quantity of naphthenes present must be taken as very approximate, since no accurate method of determining these is known This may account for the considerable difference in the H.U.C.R. for Nos. 1 and 3 whilst the analyses are in close agreement, almost within the limits of analytical error.

That benzene, either alone or in admixture with petrol, frequently enabled an engine which was giving detonation trouble with petrol, to run for some considerable time without decarbonising, was well-known to most motorists. Ricardo's work has emphasised the advantages of a motor spirit containing a fair proportion of benzene and its homologues. In comparing the three hydrocarbons of the aromatic series which fall within the range for motor spirits, Ricardo found that toluene was most efficient for preventing detonation and proposed a relative value for this character of different hydrocarbons, which he termed the "toluene value." Toluene with a value of 100 is the standard, xylene has a value of 85 and benzene of 67. In the British Engineering Standards Association specifications a "toluene value" for aviation spirit is laid down, in agreement with the specification of the Royal Air Force.

WORK OF U.S.A. INVESTIGATORS.

The problem of detonation and anti-detonating fuels and compounds has been widely investigated in the United States, and more particularly by Midgley and Boyd. Their apparatus was very ingenious, a single cylinder air cooled engine with four detachable heads which enabled compression ratios of 3.47:1, 3.87:1, 4.59:1, and 5.36:1 to be obtained. The detonation was quantitatively measured by causing a circuit in a continuous current system with water electrolysis apparatus in the circuit, to be closed, so generating a measurable quantity of gas. On top of the cylinder of the engine a cylinder was fitted carrying a piston, and resting on this piston was a "bouncing pin," above which a pair of contact points were fixed, these being in the continuous current circuit. The piston was held down by a powerful adjustable spring. With normal combustion the piston was only raised slightly and the bouncing pin did not engage the make and break. When a detonation occurred contact was made and electrolysis took place.

Midgley and Boyd used kerosene instead of petrol because detonation can be induced at lower pressures. As a standard for comparison, kerosene and xylidine mixtures were used, it being well known that aromatic amines were much more potent as knock-reducers than the aromatic hydrocarbons. One per cent. of xylidine added to a fuel with detonating tendencies enables the compression to be raised about 10 lbs.

As a result of these experiments it was shown that xylene was better than toluene and the latter better than benzene. Alcohol was much better than either.

The addition of small amounts of aromatic hydrocarbons to paraffin fuels was found to have but a small effect in suppressing detonation, and Midgley and Boyd concluded that not less than 20 per cent. of benzene was required to be effective.

The relative value of xylene, toluene and benzene is evidently open to some question in view of the contradictory results of Ricardo and of Midgley and Boyd. As pointed out by S. W. Sparrow, in two cases Ricardo obtained widely divergent toluene values for the same fuels. In one case the variable compression engine gave a toluene value of 28, and the same fuel in a super-charging engine 18; in the other case the respective values were 35 and 24. In practically all other cases the agreement was very good, but in view of these considerations it would appear that the adoption of toluene as the standard of reference was perhaps premature.

One of the natural outcomes of these results has been the investigation of a large number of substances which might have still better anti-detonating characters, and several (not themselves actual fuels) have been discovered. The following table summarises some of Midgley's results.

Compound.	Corresponding per cent. by volume.	Corresponding number of molecules of theoretical fuel/air mixture to one molecule of anti-detonator.
Benzene	25	150
Ethyl iodide	1.6	2,150
Xylidine	2.0	2,600
Tin tetra-ethyl	1.2	7,100
Selenium di-ethyl	0.4	11,750
Tellurium di-ethyl	0.1	50,000
Lead tetra-ethyl	0.04	215,000

In addition to xylidine several other nitrogen compounds are effective. For example, aniline, but the primary and secondary amines, particularly diphenylamine, are the most effective of this class.

On the other hand certain compounds will induce detonation, thus organic nitrates and nitrites—isopropyl nitrite being a good example. An engine running quietly on a benzene-petrol mixture will begin to detonate if a bottle of this compound is held near enough to the air intake for the vapours to be drawn in, the same effect being produced if a little of the compound is dissolved in the fuel. One gram molecule of isopropyl nitrite has a knock-inducing effect equal to the anti-knock effect of about one tenth of a gram molecule of lead tetraëthyl.

No satisfactory explanation has been suggested of the action of these almost infinitesimal quantities of certain compounds in suppressing or inducing detonation.

A point of particular interest is that the addition of such a powerful anti-knock as lead tetraethyl certainly does not raise the spontaneous ignition temperature of a fuel, neither do knock-inducers lower it, indeed Ormandy and Craven have stated that the effect of either is directly the reverse.

The discovery of the remarkable effects of these anti-knock compounds quickly led to the practical application of the most effective of them, lead tetraethyl. It was stated in 1924 that 200 million gallons of gasoline containing the compound had been distributed in the previous two years from some 20,000 filling stations in the United States.

Used alone, trouble has arisen from the deposition of lead on sparking plugs, etc. The trouble has been overcome by adding small quantities of volatile organic halogen compounds, so that on combustion the lead is mainly converted to lead chloride or lead bromide, and is mostly blown out with the exhaust gases.

ETHYL FLUID is the commercial name for the concentrated solution of the lead tetraethyl and ethylene dibromide which is distributed in small sealed cylinders which can be punctured through the cap in a special adjunct to the petrol supply. The liquid is specially coloured to distinguish it, because of its highly poisonous properties.

ETHYL GASOLINE is the ordinary motor gasoline to which the ethyl fluid has been added, approximately in the proportion of 3c.c. of lead tetraethyl and 2c.c. of the halogen compound—ethylene dibromide or trichloroethylene to the American gallon. This approximates to about 0.06 per cent. by volume of the tetraethyl and 0.04 per cent. of ethylene dibromide.

POISONOUS EFFECTS OF LEAD TETRAETHYL.

Unfortunately the manufacture of the compound has led to some fatalities, and several non-fatal cases of poisoning, and at the end of 1924 it was stated that no more "ethyl gas" would be placed on sale for a time, pending the reports of Committees conducting investigations of the risks involved in manufacture and to users. It is stated to be about one twenty-fifth as toxic as mustard gas. It finds entry to the system through the fatty tissues and is deposited in various parts of the body including the brain. The effect is not cumulative, however, as with most lead poisoning. This poisonous character of lead tetraethyl is certainly a drawback from the point of view of manufacture and distribution, but now that this danger is realised there seems no reason why methods which were successful for the manufacture of highly toxic war gases should not be equally applicable in this case.

There is another but distinct aspect of this question—the dangers from lead compounds in the exhaust gases. This question has been investigated by a strong Committee of experts in the United States and a valuable report has been issued (Dept. of Interior; Bur. of Mines, No. 2661). The main conclusion was that " no indication of plumbism was found in any of the animals (over 100) used, although they were exposed for 188 days during a period of approximately 8 months to exhaust gases from ethyl gasoline in concentrations with respect to lead content that are several times that allowable from the standpoint of the carbon monoxide." The risk of the public from the use of lead tetraethyl still seems to be an open question, for an announcement was made in May that sales had been suspended pending a conference called at the instance of the Surgeon-General of the United States.

The bulk of the lead compounds condense in the exhaust pipes and silencer, 80 per cent. being so deposited in one series of tests. Experiments with men showed that 75 per cent. of the very fine lead fumes inhaled was again expired and of the 25 per cent. not so disposed of a considerable part was eliminated in the secretions and by expectoration.

Care would naturally have to be taken in dealing with the deposit in the silencer, etc., and when decarbonising.

The discovery of these compounds with such high anti-detonating properties undoubtedly marks almost an era in the development of internal combustion engines. Already an experimental motor with high compression has been built in which the miles per gallon of petrol have been raised from 16 to 31.5 m.p.g.

The development of special motors to use such fuels must, of course, be dependent upon supplies of suitable fuel being always available; the distribution arrangements must be on as universal a scale as for ordinary petrol. Yet such anti-detonating fuels may be of service with motors of the ordinary compression ratios, because decarbonisation may be at less frequent intervals, although this may not be an entirely sound proceeding.

Where, however, special provision of fuels containing anti-knock compounds can be arranged with certainty of maintaining supplies, their use may have important developments. Thus, for air-craft, expecially for military purposes, there are possibilities of considerably increasing engine efficiency. Again for naval purposes anti-detonating fuels should prove of value, especially with craft using higher range distillates than ordinary petrol, it being well known that the tendency to detonation is higher the higher, the boiling range of the paraffin hydro-carbons.

There is a production question of some importance, the provision of bromine for the manufacture of lead tetraethyl. In time of war doubtless large quantities of bromine will be required for poison gas manufacture, and during the late war difficulties were experienced in meeting the requirements. The recent announcement that the Ethyl Gas Corporation of New York had fitted out a ship for the production of bromine at sea—a floating chemical works—is of some interest in this connexion.

MIXED FUELS.

But brief consideration can be given to some of the more important points in connexion with these. Almost all possible combinations of volatile combustible liquids have been granted patents, yet the number of patented mixtures continues to grow. Ormandy has wittily described them as " the type of patent which adds to the gaiety of an otherwise sombre publication." It certainly seems possible to obtain a patent for any mixture, provided someone has not previously obtained protection for the same ingredients in practically the same proportion, or for a mixture in which some small amount of a new substance is introduced for which some specific virtue is claimed. The large majority die natural deaths; in the minority are few which it is worth anyone's money to contest. How many would stand up to the challenge of the law courts is problematical.

Although a very large number of mixtures have been suggested, the principal may be classified as:—

1. HYDROCARBONS ONLY: e.g., petrol/benzole; petrol/tetralin; petrol/benzole/tetralin.
2. HYDROCARBON-ALCOHOL: e.g., petrol/alcohol; benzole/alcohol, petrol/benzole/alcohol.
3. ALCOHOL WITH NO HYDROCARBONS: e.g., alcohol/ether.

The use of petrol/benzole mixture (usually equal volumes) is now very general. The advantage of the benzole has been amply demonstrated by experience and by Ricardo's researches. One point only requires mention, the separation of small quantities of water when the mixture is made. A gallon of benzene saturated with water at 15°C. contains 2.45cc. water. Much of this is thrown out of solution when the petrol is added. Proper settling must be allowed for few commercial benzoles are " dry." Where a mixture has been made in the tank of a car trouble from water collecting in the carburettor has not infrequently occurred.

Tetralin (tetrahydro-naphthalene) has been used fairly extensively in Germany. " Tetralinbenzin " is a mixture with petrol; experience shows that less than 50 per cent. of tetralin should be present. Another mixture appears to have been officially adopted as " National Motor Spirit " (Reichkraftstoff) and consists approximately of benzole, 50 per cent., alcohol, 25 per cent., tetralin, 25 per cent. Sir Frederick Nathan has given a full account of tetralin and its mixtures in FUEL, (1924, 3. 346).

Alcohol-Hydrocarbon mixtures present difficulties owing to the liability of separation of constituents, particularly at low temperatures, when water is present. Commercial power alcohol never contains less than 5 per cent. of water. Addition of petrol or of benzole is only possible within rather restricted ranges without the separation of constituents. Benzole is much better than petrol in this respect. Ninety per cent. aqueous alcohol will dissolve about four times its weight of benzene but only one third of its weight of hexane.

The use of a third substance to increase the stable mixture range has been suggested, and higher alcohols—such as butyl and amyl, which are constituents of " fusel oil "—have proved the best materials. Ormandy and Craven, who have investigated these solubility problems, point out, however, that to add 10 per cent. of alcohol to Pratts No. 1 Spirit at 15°C. the alcohol would have to have a strength of 95.8 per cent. by weight; if 5 per cent. of amyl alcohol were also used it would only enable the alcohol strength to be reduced to 93.2 per cent.

So difficult is this problem of separation due to the presence of water that much attention has been given, particularly in France, to the possibilities of producing anhydrous alcohol at a sufficiently cheap rate to render its use feasible. It has been reported that one firm in France has arranged plant for the production of 22,000 gallons per day.

Alcohol mixtures for aviation have been investigated by the Bureau of Aeronautics, Navy Department, U.S.A. H. A. Gardner states that a 30/70 alcohol/gasoline mixture showed turbidity at —46 to —60°C. The presence of 0.5 per cent. of water raised the turbidity point to —10°C. He also pointed out the hygroscopic character of absolute alcohol mixtures, quoting a case where 10 hours exposure to damp air caused sufficient water absorption to produce separation.

A proportion of benzene enables alcohol/petrol/benzene mixtures of a fair range of stability to be made, thus the addition of 15 per cent. of benzene to 67 per cent. of 95 per cent. alcohol and 33 per cent. of petrol is stated to give a mixture stable down to—5°C.

Alcohol mixture fuels have been subjected to extensive tests in both experimental engines and under the more severe test of service conditions and many mixtures have given excellent results. In particular, mention should be made of the series of tests made by the London General Omnibus Company and those made on air-craft engines on " Alcogas " in the United States. An alcohol/petrol/benzole mixture (" Discol ") is in use in London. In South Africa large quantities of an alcohol/ether mixture (" Natalite ") have been used.

The practical worth of the mixtures and their general advantage of withstanding high compression and so giving good efficiencies has been amply demonstrated. One important point remains for consideration, continuity of supply. Particularly is this vital in war time. Alcohol is in large demand for the manufacture of explosives. It was stated that in the later stages of the Great War the requirements were some 1,200 tons weekly. The shortage of alcohol was generally known, also the fact that the Government had to reserve all stocks. Under similar circumstances could it be expected that alcohol would be available for fuel ?

Whilst in peace time the use of mixture fuels is advantageous, the very important question of supplies in war time of fuels suitable to the type of engine in use must be ensured, for motor transport is to-day essential to the fighting forces and the non-combatant population. It will be of no use if special types of engines suitable only for particular types of fuel are developed in peace time, if in war time the demand on the ingredients is so great for other purposes that the special fuels are not available. On the other hand there can be no question of the desirability of developing home production of benzole to the highest possible output. Motor benzole contains a considerable proportion of toluene, for which the demand would be great in war time, another good reason for the establishment of benzole production on the largest possible scale, for there should be a large benzene surplus after the toluene demand had been met.

COMMERCIAL CONDITIONS IN CHIENGMAI (SIAM).

In reporting on the trade and commerce of his district, H.M. Consul-General at Chiengmai points out that the Chiengmai Consular District comprises two Siamese Provinces, Payab and Maharat. The population is about one and a half million, including upwards of 16,000 British subjects, mostly Burmese and Shans. There are some 2,000 Indians and about 100 European subjects. The district is entirely inland.

The only trade statistics obtainable are still those showing the trans-frontier trade with Burma, supplied by the Commissioner of Settlements and Land Records, Rangoon. At the present time this trans-frontier trade has ceased to be, as it once was, the principal trade of the district (exclusive of teak). Now most of the trade is carried by rail.

Trade with the Southern Shan States, particularly Kengtung, has greatly increased of late years, and a constant stream of pony and bullock caravans may be seen passing along the road which leads northwards to Kengtung. Unfortunately no statistics of this trade are kept. Some of the goods carried by this road are destined for Yunnan, so that Bangkok is to-day a seaport not only for some of the British Shan States, but even for parts of China.

IMPORTS.—Cotton manufactures are the principal article of import from Burma, and the same may be said with regard to goods brought up by rail. The total value of cotton manufactures imported by all routes is estimated at somewhere about £250,000. The goods are mostly British.

Among other articles imported by rail are petroleum and petrol, motor vehicles, matches, china and glassware, cutlery, etc.

Motor vehicles (cars, 'buses and lorries) are now imported almost every week, the total number already in Chiengmai being over 90—a good number for a place where the road mileage permanently available for traffic is only about 50 miles.

EXPORTS.—*Teak.*—Teak logs, mostly belonging to British firms, are exported from the district by the simple method of floating them down the various rivers. The annual value of logs floated each year down the rivers which flow south is about £1,000,000. The Salween river receives about one-tenth of these, all worked by a British firm. The Mekong river is the channel for rather more logs than the Salween, practically all worked by a French firm. The teak industry is the life and soul of Northern Siam. Where teak is worked there is prosperity and progress; in other places comparative stagnation.

During the financial year ending March 31st, 1924, 111,184 logs passed the duty station at Paknampho, and 14,500 paid duty to the officer in charge of the Mekong forests. These figures are good, but cannot be taken as an indication of the number of logs actually extracted during any given year. As for Paknampho, many logs do not reach that station for several years after they have been extracted from the forests.

Rice.—Of late years a constantly increasing amount of paddy has been exported by rail. There are, moreover, now several rice-mills in the district which export husked rice. In many places Chinese speculators purchase the crops ahead, and there is a tendency to sell too much, the margin retained for food being insufficient. Some districts have been on the verge of famine once or twice. The rice export business has given a stimulus to agriculture, and a great deal of waste or jungle land is being reclaimed for cultivation.

Sticklac.—During the last two years there has been a small boom in the cultivation and export of sticklac. Experiments are being made in cultivating it on various kinds of trees on which it has not hitherto been produced. It is a very easy and profitable industry.

Silk Piece-goods.—The export of Chiengmai silk, which is both durable in quality and artistic in design, is increasing. In 1923 raw silk worth over £11,000 was imported from, and over £8,000 worth of manufactured piece-goods were exported to, Burma. The amount sent to Bangkok is far greater than this, and the demand is steadily increasing. Chiengmai silk skirts are now the recognised costume for Siamese ladies of good position.

COMMUNICATIONS.—During the period under review the State railway maintained a very regular and efficient service both of passengers and freight. Complaints, except as to the high rates charged, are now rarely heard.

Steady, though very slow, progress is being made in extending the various roads leading from Chiengmai to neighbouring villages, as well as in the extension of the Lampang-Muang Ngao road towards Chiengrai. Motor vehicles actually ran more or less regularly to Chiengrai between December, 1923 and April, 1924, but a single shower of rain is enough to make the northern part of the road impassable.

The new steel bridge over the river Me Ping at Chiengmai, 218 yards in length, was completed at the end of 1923. It was supplied by a well-known British firm, and is a great success. Chiengmai has never before seen a bridge over which elephants and motor vehicles can be allowed to pass without restriction.

GENERAL.—Taking things all round, the district may be said to be going slowly ahead. From year to year there do not seem to be great changes, but by looking back for twenty years it is easy to see what great progress has been made in every direction.

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PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

RADIOLOGICAL RESEARCH—A HISTORY.

By V. E. Pullin,

Director, Radiological Research Department, Woolwich.

Lecture I.—*Delivered 19th January, 1925.*

"The light shineth in the darkness and the darkness comprehended it not."

In accepting the honour of delivering these lectures on the subject of Radiology, I am conscious that the subject has quite recently been very ably dealt with. It occurred to me, however, that a consideration of the development of scientific research which led up to Röntgen's discovery and, further, a short survey of the effect of this momentous revelation on scientific progress would refresh your minds, and so possibly stimulate a renewed interest in it, and also, I hope, encourage more young scientific men to devote themselves not only to the study and development of this most fascinating and useful branch of physics, but also to talk of it in the vulgar tongue. We must familiarise the public with our work if it is to progress, as it should.

The history of human thought from the earliest time presents one long panorama of search, the search for the light which has shone for all time. Modern scientific workers, I am sure, do not always realise the great debt which they owe to early philosophy. Not only was early philosophy responsible for the system of modern thought, but it also provided from time to time that solid rock of invincible orthodoxy upon which pioneer scientists, unorthodox of the unorthodox, could sharpen their teeth and wax lusty and strong. Early philosophy behaved towards science very much as the Devil towards mankind, who, far from meaning any harm to us by his machinations, merely intends that our virtue shall not languish from want of exercise.

There is no doubt that in the beginning man's thought was concerned solely with natural phenomena. He observed the heat and the cold, and the light and the darkness. Man was first, therefore, essentially a physicist. Subsequently the fascination of speculative essays produced the chaos which we read of as characterising early Greek philosophy. Physics came first and then metaphysics. Out of strength came forth sweetness! We will accept for the moment the definition of philosophy according to Herodotus to imply the idea of the pursuit of knowledge. It is only one of many definitions; Plato, for instance, defines the philosopher as one who apprehends the essence or reality of things in contradistinction to the man who dwells on appearance or things of sense.

Perhaps the most general tendency of the early teachers was to satisfy man's insatiable curiosity with regard to a first cause on the one hand, and the manifold natural phenomena around him on the other; but even in these far off days, remote from polytechnics, science had her votaries. Such men as Empedocles, and later Democritus, sought to approach reality entirely through the medium of natural things, and of this system was born the atomic theory which has been immortalised by Lucretius. Empedocles believed that if the four elements—fire, water, air and light—were mixed in suitable proportions, then any manifestation was possible. Pure unadulterated Prussianism! Scientific progress would appear always to have been "agin' the government," and so the early efforts of these pioneer scientists, Anaxagoras, Hippocrates, and the rest, were often near to being stifled by the orthodox mystic school, which ultimately found its fullest expression in Plato.

Plato was concerned not so much with natural phenomena as with reality, the ultimate prime-mover; and the Platonic school, which became universal, developed into a dialectic system of interchanging abstract conceptions. It was, however, the dawn of *scientific method*. It sought to clothe and succeeded in clothing ideas with *words*, and so prepared a suitable cradle for that wonderful system which was to follow. The dialectic of Plato may be regarded then as the first real corner stone in the scientific edifice. The next stone, of course, was Aristotle, who, beginning in the ground so well tilled by the existing school, in much the same way that Plato had started on ground prepared by the definitions of Socrates, was able to construct that marvellous and enduring system which was to be the beginning and end of all knowledge for so many centuries. By his system of deductive reason, Aristotle, as it were, fitted the wheels to the hitherto stationary vehicle of rhetoric said to have been invented by Empedocles, but, undoubtedly, constructed by Plato. It was now possible to reconcile observed phenomena with the spiritual necessity of man in a way that had never been done before. Through this new system of reasoning, which is still, perhaps, the most potent weapon in our modern armoury, Aristotle was inspired with the enunciation of the first scientific principles, and it is, of course, to him that we owe the first general classification of the sciences.

Science had now become the attribute of erudition ; and might be fitted into the fashionable school of thought by means of this new system of logic, rather than regarded as the bag o' tricks of unorthodox quacks as heretofore. The scientific influence of Aristotle is illustrated by the development of many specialised scientific schools. It produced, for example, Archimedes, who was the first practical physicist. The strongest and most marked development of Aristotelian thought, however, was expressed in the subsequent universal scholasticism, which ultimately became the current philosophy of the Christian Church, and, as such, provided the atmosphere and rule of every school and university of Western Europe. The result was the establishment of multitudinous theological schools, and the development of theological disputes of, what then appeared, the greatest possible consequence.

In this scholasticism, science was well nigh lost, but St. Thomas Aquinas, in the middle of the thirteenth century, deserves notice. He certainly contemplated science. True, he contemplated it through theological glasses, which had been optically corrected to eliminate everything save the most orthodox. Nevertheless, he allowed the importance of the classification of natural phenomena in the general scheme of things. His great work, "Summa Theologica," was intended to be the sum of all known learning, and, as scientists, we must gratefully realise that science had its place.

At this time, 1219-1224, it was the privilege of Oxford University to produce one Roger Bacon, a Franciscan Friar, of sadly unorthodox views. He was an *experimental physicist*, which was not to be tolerated. To the more conservative of us it is consoling to read that he was condemned to prison for this grave heresy. His chief scientific activity would appear to have been alchemy, and especially in searching for the pure red sulphur which was gold and that purity of mercury which was silver. But, nevertheless, it *was* experimental science, and it endeavoured to break away from that pseudo-science of the schoolmen which rested on arguments deduced from abstract ideas strictly within ecclesiastical authority. Roger Bacon, then, that arch-quack, may be regarded as another highly important stone in the scientific edifice.

Time is short, and it is impossible to mention the various sporadic efforts that were made for science in the next few centuries. In the beginning of the 17th century we have another quack, this time an astrologer, one Kepler, upon whose work modern science so much depends ! In 1600 also we must consider for a moment Francis Bacon, that most eminent scholar, experimental physicist, lawyer and philosopher. Bred and educated in the very home of English orthodoxy, the University of Cambridge, he early rebelled against the philosophical system which contained so many names for non-existent things and yet which were supposed to exist merely because they had names. Bacon's methods illustrated the extreme swing of the pendulum. His system of reasoning was purely inductive. But it is worthy of notice, and it is most undoubtedly true, that it is due to Bacon that very many current religious opinions were transferred from the realm of reason to their more proper one of faith.

At this period, too, we must regard for a moment that other great name in scientific martyrology, Galileo, and the only comment I shall make is to read an extract from the Proceedings of a Congregation of Prelates and Cardinals in the year 1632:—

> "The doctrine that the earth is neither the centre of the universe nor immovable, but moves even with a daily rotation, is absurd, and both philosophically and theologically false, and at the best an error of faith."

This illuminating comment on Aristotelian orthodoxy remained in force until early in the nineteenth century!

Having considered the general progress of science very roughly, we now arrive at a period where we must trace more particularly the development of our own subject. In the middle of the 17th century, we have the first name of importance to radiology—Otto von Guericke—who, not only gave us the first electrical machine, but also invented the first vacuum pump. Incidentally, he may be regarded as the founder of that very virile school to which Newton traced his intellectual descent. Early in the 18th century Newton, of course, put physics on quite another footing.

At this time scientific events began to develop along experimental lines. But I want to direct your attention particularly to the year 1705, which must be regarded as the beginning of radiological research.

X-rays are produced artificially by means of a bulb—generally a glass bulb from which most of the air has been withdrawn—through which bulb an electric current is passed. Generally this operation is accompanied by a visible fluorescence or glow in the bulb. The essential feature, however, in the artificial production of X-rays is the passage of an electric current through an exhausted bulb.

In 1705, Mr. Hawksbee, F.R.S., when experimenting with the then popular vacuum, observed flashes of light in a glass tube on agitating the mercury it contained. He did not associate this phenomenon in any way with electricity, but rather regarded it as an attribute of the mercury. He found that even in a partially rarefied atmosphere he obtained the same effect. Hawksbee proceeded with these experiments, and in 1705 he communicated to the Royal Society an account of his observations entitled, "On the Attrition of Bodies in Vacuo." In my next lecture I hope to show you an illustration of this apparatus, when we will consider the methods he adopted in a little more detail, but here we have the first account of an electric discharge in an evacuated bulb, the first embryo X-ray apparatus. The next step of importance in this respect is contained in an account of the observations of one Abbé Nollet, in Paris, published in 1753. He used a Guericke pump and electric machine, exhausted glass bulbs, passed electric discharges through them, and observed the accompanying glow.

The next account of interest is contained in a paper read to the Royal Society in 1785 by Mr. William Morgan, to whom, I think, we must give the credit of being the first experimenter to produce X-rays. The phenomenon of the glow accompanying an electric discharge through a vacuum would appear to have been well known at this time. Morgan's advance consisted in the fact that on decreasing the gas pressure in his bulb he obtains what he describes as a beautiful green colour, which altered from green to blue and so on to violet and purple as he allowed gas to enter the bulb.

We now come to a period of the greatest possible importance in the history of electrical development—the beginning of the nineteenth century—and events crowd upon each other so thick and fast that it is impossible to mention them all, and we must, therefore, merely consider those which have a direct bearing on our subject. The names of Davey, Ampère, Ohm and Faraday, of course, all demand our greatest veneration. Ampère's discovery of the magnetic action of one current on another, was followed by Faraday, who showed that rotation produced a current round the magnet, and his discovery of conduction of a current in a closed circuit by a moving magnetic field, was followed by the dynamo, the transformer and the induction coil.

To resume the consideration of steps in our radiological progress, we find that Sir H. Davey repeated Morgan's vacuum experiments in 1821, and described various green lights which he obtained, some of which were probably mercury vapour light, but it is certain also that he produced electronic bombardment of the glass and consequent fluorescence. Prior to 1838 Faraday took up the study of electric discharge in vacua in the course of the development of his theory on dielectrics. He observed a dark space round the negative electrode. This observation, of course, opened the way for all future work on the subject. As a result of Faraday's work radiological investigation began to converge, as it were, to a focus. General apparatus was improved and other workers entered the field. Unrecognised, the ubiquitous electron was battering the glass walls of his prison house in unremitting efforts to be known. Plucker, in 1859, succeeded in obtaining vacua good enough to enable him to observe fluorescence in the glass walls of his vacuum tube. Ten years later Hittorf became aware of a stream of radiation proceeding from the negative electrode in an exhausted bulb. His impression of it is vividly conveyed to us by the name he gave it, *the negative glow-light*. It was, of course, what we now call the Cathode Stream or Rays. Attention was now very closely focussed on electric discharge in vacua, and in 1879 Sir William Crookes demonstrated all its properties, including its normal emission from the cathode; that it could be focussed from a curved surface;

the production of fluorescence when it hit the glass walls of the tube; the production of heat when it impinged against a solid obstacle, and its deflection by a magnetic field. He suggested that here was matter in a *fourth state* or *radiant matter* (a conception, by the way, originally put forward by Faraday). He believed that the cathode stream was composed of molecules, or, at any rate, of *matter* of molecular dimensions. He suggested that these " molecules " carried a negative charge as indicated by their magnetic deflection. Then the controversy began. Hittorf at once challenged Crookes's conclusions and denied any propagation of gas particles. Crookes's explanation of the nature of the cathode stream was very generally accepted in this country, but many foreign physicists, particularly the German school, were of the opinion that it was another manifestation of *ether* waves.

We will pause for a moment to consider what we mean by this word " ether." Then, as now, it was used in a sense to convey an idea of that medium which would transmit energy. It was, then, as now, a word which transcends definition. It has some sort of a parallel perhaps in the " substantia " of schoolmen, who found this idea a very useful adjunct in explaining some of the more difficult conceptions involved in those elementary articles of faith, which constituted such a tiresome difficulty in the minds of the unlearned.

In 1883 Prof. J. J. Thomson first put forward a theory of gaseous discharge based on the principles of electrolysis, conduction by ionization. He supposed the molecules of gas to absorb energy from the electrostatic field and become decomposed into free ions, again supporting the material view of the phenomenon. Soon after, Hertz, working at Bonn, demonstrated that the cathode stream would pass through a film of gold or aluminium placed in its path. In 1894 his work was continued by Lenard, who, by sealing a thin aluminium window into the wall of his discharge tube, was able to show that the cathode stream passed through it. Lenard also remarks that these rays can pass through the hand. It is obvious now, of course, that some part of Lenard's results were due to X-rays, but the immediate result of his experiments was to support the view that the cathode stream was due to ether vibrations. It certainly appeared that the passage of molecular particles through solid matter was an insuperable objection to Crook's theory.

In 1895 Perrin proved that the cathode stream carried a negative charge. He arranged a metal cylinder in a vacuum tube and connected it to an electroscope, and, by a magnetic arrangement, he diverted the cathode stream into the cylinder which at once acquired a negative charge. The controversy as to the nature of cathode rays was now at its height, and physicists all over the world were endeavouring to deduce experimental evidence to support one or other of the two theories. From the amount of work that was reported at this time, it is quite clear that a virile controversy acts as a particularly powerful stimulus even to that dispassionate and impersonal body, the scientific world. I will read you an extract from a lecture delivered by Sir George Stokes about this time, in which the position is very admirably summed up :—

> "Nobody, I suppose, denies that there is matter propelled; but there has been considerable difference of opinion as to whether the matter propelled is of the essence of the phenomenon, or whether it was merely something accidental. Mr. Crookes held that it was of the essence of the phenomena, and that we had here really a stream of molecules, and I must say for my own part I believed he was right, but some foreign men of science held that the projection of matter is altogether a secondary phenomenon and that what comes through this small hole is really only a process which goes on in the ether, something so far of the nature of light, but yet differing from ordinary light most markedly in the property of being deflected by a magnet. To illustrate what I mean by saying something secondary, Prof. Wiedemann, who holds the opinion that it is of the nature of light, or a process going on in the ether, imagines that the progression of matter has no more to do with the phenomenon than the path of a cannon ball has to do with your hearing the sound of a cannon."

This concentrated work on the cathode stream was bound to result in fresh discovery, and it did. Röntgen read his epoch-making paper announcing the discovery of X-rays at the end of 1895. Apart from the momentous announcement, the paper was most remarkable in that Röntgen's view of the general properties of X-rays was so wonderfully accurate in the light of our later knowledge. He recognised that the new radiation was similar to light, but he explained that the absence of reflection, refraction and interference suggested that the two were not identical. In consequence he was driven to put forward the hypothesis that his rays were longitudinal ether waves as distinct from the transverse waves of ordinary light.

This particular view of the nature of X-rays was immediately criticised. Prof. Schuster pointed out that there was no evidence that the new rays were not ordinary light vibrations of a very short wave-length. *He went on to suggest that possibly we had here the vibration of the electron within the molecule. He also emphasised the difference between cathode and X-rays.* These views are, indeed, remarkable for their prophetic accuracy. We must be careful to remember that at this time the existence of free electrons had not yet been recognised. Dr. Johnstone Stoney had, indeed, used the word to denote his conception of an indivisible unit of electricity to fit in with his theory of electrolytic conduction. Lorentz also had attempted as early as 1878 to explain the properties of dielectrics by a theory of charged particles residing within the molecule, but the idea of electrons playing any important part in physical phenomena was entirely alien to all schools.

J. J. Thomson, in 1895, discussed the question of the nature of the new rays from the point of view of the electromagnetic theory. He pointed out that short longitudinal ether waves were possible and that they would not be refracted, but he also showed that short transverse waves also would not be refracted if the wave-length were comparable with molecular distances.

It will be seen that the old cathode ray controversy was now complicated by one equally acute on the nature of the new rays. What were X-rays? Were they, too, material particles, of a more rarefied nature than the cathode rays, or, were they, as their discoverer suggested, a form of light of such a curious kind that it would not obey the laws which governed ordinary light? Where did they originate? Wherever they appeared the glass walls of the tube fluoresced. Was this a necessary phenomenon or was it merely incidental? That the rays arose somehow from the stoppage of the cathode stream was quickly recognised. The first clear statement of this fact appears to be due to Prof. Porter, who incidentally was one of the earliest users of the "focus" type of tube. The very close association which had been observed between the cathode rays and the X-rays gave rise to the idea that the two had the *same nature*, and the idea persisted for a very long time in spite of the recognised fact that magnetic deflection was possible in one case and not in the other. Then both J. J. Thomson, at Cambridge, and Benoist, in Paris, discovered that X-rays would discharge a charged conductor.

This was another piece of progress, but it did not, at the moment, contribute to any definite view of their nature. It is very interesting to recall an erroneous conclusion of J. J. Thomson's about this time. As a result of his experiments, he was of the opinion that *all substances*, including ebonite, paraffin wax, etc., when transmitting these rays, became conductors of electricity. He again suggested that the leakage of the charge is due to the splitting up of the molecules, *i.e.*, as in electrolysis. Thomson had already concluded from experiments on absorption that X-rays were not all of the same kind, and Chabaud, in Paris, found that X-ray absorption by metals increased with the atomic weight of the absorber. It is to be expected, as was indeed the case, that very many workers in the early months of 1896 concentrated on attempts to reflect or refract X-rays in order to lend support to the wave theory, but the results only tended to confirm Röntgen's original statement that the rays so treated were only scattered or diffused. Prof. Pupin, of New York, suggested that these diffusion effects were very similar to Lenard's results with cathode rays, and that possibly magnetic deflection did, indeed, take place and was marked by diffuse scattering.

Other writers of this period emphasized J. J. Thomson's view that reflection and refraction were not to be expected if the rays were light waves of extreme shortness. An independent view was put forward by Prof. Michelson, in April, 1896, who propounded his "ether vortex" theory, having given reasons for rejecting the two current views. He suggested that "ether vortices" were forced out from between the molecules of the cathode by the negative charge. He also considered that X-rays and cathode rays had the same nature. This theory was not destined to play any very important part in the controversy, nor does it bear very much on the subsequent development of the subject. Prof. Righi, in Italy, and J. W. Giltay, of Holland, and Prof. Haga, of Groningen University, record observations on the action of X-rays in discharging electrification. Early in 1896 Becquerel discovered radioactivity. It was a natural phenomenon, and not artificially produced like X-rays. It was, as we know, the *spontaneous* break up of the Uranium atom, but the results were very like the newly discovered X-rays, and so naturally created a very great stir. The similarity both to light and also to X-rays was at once emphasised by the " wave " theorists. J. J. Thomson pointed out that the new radiations are like light since they can be polarized and refracted, and could penetrate solids like X-rays, and from the point of view of the wave nature of X-rays he referred to Becquerel's discovery as " evidence of a more positive character." He also thought it likely that if a fine enough medium were found it would be possible to polarize X-rays.

Sir George Stokes, in his presidential address to the Victoria Institute, also referred to the subject. He suggested, in dealing with Röntgen's observations on scattering, that the Röntgen rays falling upon a metal throw the molecules into a state of vibration, which they communicate to the ether by a similar sort of mechanism to that of phosphorescence or fluorescence in the case of light. This is a most remarkably accurate forecast of characteristic radiation, which, of course, I shall refer to later. He, too, remarked that polarization would be possible if the right means could be found. At a meeting of the British Association in 1896, Lenard personally described his own experiments. He concluded that X-rays were of the same nature as cathode rays and were probably deflected by a magnet, but inasmuch as they were of a modified form such deflection would be very slight.

A mass of other work was done producing results of more or less interest. Two or three workers thought they *had* produced diffraction X-rays by passing them through a narrow slit. 1897 saw the virtual end of the great cathode ray controversy, thanks to the classical experiments of Prof. J. J. Thomson.

If the cathode rays consisted of charged material particles, it was necessary that they should have a finite mass. It was already known that they carried a charge. Thomson succeeded in determining the ratio of charge to mass $\left(\frac{e}{m}\right)$ for these particles by passing a beam of the rays through crossed electric and magnetic fields so balanced that the deflection produced by one neutralized that of the other. Wiechart and Kaufmann, in the same year, obtained similar results. Whatever the nature of the gas or the material of the electrodes, this value of $\frac{e}{m}$ was found to be always the same, and it was *from seven hundred to nine hundred* times the value of $\frac{e}{m}$ for the *hydrogen ion*. Thomson concluded that the charge was the same as for the hydrogen ion, and that the cathode stream was, therefore, composed of particles having a mass *very much* smaller than that of an atom, and, moreover, that these particles were *common* to all atoms. This was the first experimental evidence of the existence of the Johnstone Stoney electron.

In the following year Thomson, by employing the fascinating method of C. T. R. Wilson, by which it was possible to see these individual particles, was able to determine the value of e (the charge on the electron), and hence its mass m. Townsend also showed by experiments on the velocity and diffusion of gaseous ions that the charge on an ion of ionized gas had the same value ; and it was now realized that the process of ionization was the splitting off of one or more electrons from the atoms of gas. Here, then, was a step of the greatest importance ; but as we shall see, it was far from settling the X-ray dispute.

Just before J. J. Thomson showed that the cathode stream consisted of particles very much smaller than molecules, Sir George Stokes worked out and propounded his ether-pulse theory of X-rays. He suggested that each molecule, when it strikes against the anti-cathode of the X-ray tube, produces a perturbation in the ether, and that X-rays are made up of a succession of such pulsations spreading out spherically from the point of impact of a cathode particle; each pulsation independent of the others. If the time of these pulsations is extremely short, he showed that the theory would explain the absence of diffraction.

You will notice that the difficulty which crops up again and again is the failure of X-rays to obey the ordinary laws of optics. At this time it appeared to be the one factor against the universal acceptance of the wave theory of X-rays, but more troubles were in store.

Sagnac, in 1898, in a review of the subject, decided that X-rays were ultra violet radiations, and that their wave lengths was too short to allow any of the usual optical tests to be carried out. He therefore concentrated on the investigation of *scattering*, with the result that he observed *secondary* X-rays of different (longer) wave length, which were produced when X-rays were directed on metals. He also observed secondary X-rays from air (which had already been observed by Röntgen) and, indeed, from all substances.

J. S. Townsend also worked on this subject and showed the existence for the first time of *corpuscular or material secondary radiation* in addition. This was a most important step, and the discovery upon which the whole controversy was to turn.

In 1900 Sagnac was able to show that this secondary corpuscular radiation carried a *negative* charge, and Dorn, in the same year, showed that it could be deflected by a magnetic field. Dorn also found that this corpuscular radiation was emitted with a velocity of the order of 10^9 *cm. per second.*

Still the controversy raged. Largely as a result of the development by J. J. Thomson of the ether pulse theory and the investigations of others, notably Wilberforce and Barkla, X-rays were now *polarised.* Barkla was able to show polarisation both of the primary and secondary beams. This most important step was first communicated to the University of Liverpool in 1904, and, of course, was strong evidence for the wave theory. Haga repeated Barkla's results, using a photographic method, and concluded that X-rays were transverse ether vibrations, and showed that the longitudinal ether vibrations of Röntgen would have a different plane of polarization. This discovery would appear to have involved a crushing defeat of the corpuscular school. X-rays at last showed some sign of acknowledging a family. On the other hand, they had at the same time been shown by Townsend to yield offspring of a most undoubted corpuscular character.

Work was now very much concentrated on the study of secondary radiation and also the ionising properties of X-rays. The great velocity of the secondary corpuscular radiation had given rise to much speculation as to the source of its energy, and it was suggested that this energy might be obtained from the atom itself on the lines of Becquerel's discovery. Another source of difficulty to the spreading pulse theory was to explain why such a minute proportion of the molecules of a gas were ionised by a beam of X-rays. There did not seem to be much direct connection between energy expended and ionization produced.

If corpuscular secondary radiation was due to an explosion of the atom, then obviously the stimulus giving rise to that effect was the primary X-ray beam, but it was not easy to understand why such energy should vary with the frequency of the primary beam which had been shown to be the case by R. D. Innes in 1907.

A consideration of these difficulties and the discrepancies between current theory and experiment led Professor Bragg to return to the corpuscular theory of X-rays in a new aspect, that of *neutral pairs,* which he put forward in 1907.

In a general survey of the facts, he said that ionization by whatever agency was always produced in the same way by the displacement of negative electrons from some of the atoms.

He suggested that the ionising power or the power of being stopped of a δ particle was dependent upon its charge, *i.e.,* the field around it, and that if it were associated with a β particle, so that tubes of induction pass from one to the other tending to neutralize the whole, it would seem that the chief cause of the stopping of the particles would be removed and the penetrating power of such a pair would be enormous and its ionizing power correspondingly reduced. The limitation of the field of the pair would depend upon its moment. With this conception of the nature of X-rays, Bragg was able to explain with the greatest ingenuity all the known properties of X-rays.

They would show very little deflection in a magnetic field and the closer together they were the more penetrating would they become; they would also not be refracted.

To account for scattering and secondary radiation they—the pair—might hit on a light or yielding elastic atom and bounce off unchanged. It might be disintegrated, and the negative particle be shot off and appear as a secondary ray, or it might pick up a positive charge and reappear as an X-ray.

Bragg said that a beam of X-rays would contain some ether pulses, but that in the main it was corpuscular—and consisted of neutral pairs. There were objections to Bragg's theory, which there is no time to dwell on now, *e.g.*, Marx had in 1906 determined that X-rays had the same velocity as light, and a new life was given to the long controversy, Barkla being now Bragg's chief opponent, he being a strong adherent of the spreading pulse theory.

In 1908 Barkla and Sadler showed the existence of homogeneous radiation, similar to X-rays and characteristic of the element emitting it—and that it was probably produced by independent motion of the electrons.

In 1912 Whiddington demonstrated that the speed of electrons which comprise secondary corpuscular radiation was the same as the cathode stream electrons in an X-ray tube, and the result went to show that the whole energy of a moving electron in an X-ray tube was handed over intact to one other electron. This was, of course, a very distinct blow to the spreading pulse theory.

Bragg had definitely abandoned the wave nature of X-rays, and, no doubt, one reason was the difficulty of explaining all the observed phenomena of the classical Maxwellian light theory, and, therefore, efforts were made by some physicists to find some modification of this theory to reconcile these X-ray and light phenomena, rather than deny their similarity. J. J. Thomson, in 1908, introduced the nucleated pulse theory as a modification of the theory of Stokes, in which he imagined each electron as the seat of a single tube of electric force. When such an electron oscillates or when its velocity is changed, it will result in a pulse with all its energy travelling in *one* direction, and not spreading out in an ever-widening circle. This theory went far in explaining the similarity between X-rays and light.

During the preceding years, between, *i.e.*, 1901 and 1906, Professor Max Planck had done remarkable work on the theory of radiation, the results of which were to revolutionise current views and at the same time virtually settle the great X-ray controversy.

The result of his work involved the new idea that the energy of an oscillation can only be increased or decreased by definite finite amounts and cannot vary continuously.

When radiation energy is emitted or absorbed by an electron it can only be in *definite amounts*, the magnitude of which depends upon the frequency of that radiation multiplied by a constant. (The ratio of radiation energy to radiation frequency, which is now known as Planck's Constant.)

In 1907, Wien, starting with a knowledge of the mass and speed of secondary X-ray electrons and applying the quantum theory of Planck, calculated the wave length of an X-ray pulse and found it to be 6.75 x 10^9 cm. This most important result was immediately adopted by Prof. Von Laue as a basis in his method of devising the long sought method of diffracting X-rays.

The atom layers in a crystal were believed to be separated by distances of the order of 10^8 cm.—a corresponding dimension to Wien's X-ray wave length. Surely, then, a crystal would afford the much desired defraction grating.

Experiments on these lines resulting in the most brilliantly successful results were carried out by Friedrich and Knipping early in 1912.

Then followed that fascinating work of the Braggs, who showed that interference could be produced by reflecting X-rays from the various planes of a crystal, thus producing an X-ray spectrum which would enable either the structure of the crystal to be studied or alternatively, if its structure were known, then the X-ray beam could be examined and its constituent wave length calculated.

Here, then, at last was an end to this memorable controversy. The fact that X-rays were indeed light, of extremely short wave length or high frequency, was proved beyond doubt.

It is very interesting to note that Prof. Bragg himself by the introduction of the X-ray spectrometer went far to confirming Planck's quantum theory.

Let us consider now for just one moment what all this radiological research has meant to modern scientific development.

All substances are made up of *atoms* in some arrangement or other. I want to direct your attention for a moment to these atoms. Let us very briefly consider that most fascinating theory of atomic structure due to Professor Bohr.* We are given the picture of the atom, any atom as consisting of a central sun or nucleus holding bound up within it a store of inconceivably fierce energy. This sun or nucleus is made up of minute bodies called protons and others called electrons. We must think of the proton as being an isolated *positive* charge of electricity, and the electron as an isolated *negative* charge.

The *nature* of the atom is manifested by the behaviour of a number of planets which revolve round the nucleus in definite orbits. These planets are *all electrons* (negative charges of electricity) and they are influenced in the system of this atom universe by the excess number of protons or the *positive charge* on the nucleus. The universe as a whole may be regarded as stable when the number of protons is equal to the number of electrons. The whole atom is normally electrically neutral. Further, it resembles our own planetary universe, but with one very important exception. In the atom universe the planets (electrons) may, under certain stimuli, change their orbit, or the fixed groove as it were in which they are revolving, and when they *do* change their abode in this manner they emit a wave or pulse of radiation, the quality of such radiation depending upon where in the system they move from and where they move to.

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*The question of the structure of the atom has been mentioned merely as illustrating the importance of Radiology in modern physical progress. The various theories concerning the nature and structure of the atom are most admirably and comprehensively discussed in Professor E. N. da C. Andrade's book, "The Structure of the Atom," to which book I refer those who wish for accurate information concerning this fascinating subject.—V.E.P.

Obviously the electrons which revolve *near* to the sun, *i.e.*, in the inner orbits, are held, as it were, much more tenaciously than those which revolve in an orbit far away from the sun. This tenacity varies, of course, in the intermediate orbits. Now, if an electron happens to exist in an outermost level and falls to the next one nearer the sun, then it loses energy and the result is a wave, or pulse, of some radiation, which is sent out through the ether. In such a case it may be ultra violet radiation—that light which is nearly visible but is not. On the other hand, if the fall of the electron takes place from an inner orbit, let us say to the innermost one of all, then the radiation emitted will be of much shorter pulse or, as we say, higher frequency, and will be an X-ray. We may regard for our present purpose all such electron changes in the atom as yielding X-rays, and the precise orbits concerned in the change of abode of the electron *determine the position* of the lines in the X-ray spectrum. I want you to retain this point in your memory for just one moment.

Now the reverse is also the case—when an X-ray is impinged on an atom, according to its frequency, or we may say, its penetrating power, it causes electrons to change their orbits. Now in the same way that ultra violet light may cause the change of an electron from an inner into an outer orbit, if these orbits are at a great distance from the nucleus, and consequently allow us to investigate the behaviour of such atoms (light ones) which may have electrons in these very outer orbits, so may X-rays cause this phenomenon in the inner orbits of the more heavy or refractory, as it were, of the atoms and enable us to see what happens to these inner or very intimate electrons. If by any chance this invading radiation causes an electron to fly out of the system or atom altogether, then the whole atom becomes what we call *ionized.* It is exactly what does happen in a gas, for instance, when we pass X-rays through it. It is what we mean when we say a gas is " ionized " by X-rays.

Now the atom is investigated in the manner I have just indicated by means of the *X-ray spectrum,* which this electron change of orbit yields. We may regard X-rays then as constituting a light of such curious illuminating power that one may study with the greatest clarity the mechanism of any sort of atom. This means, of course, the nature of all elements. You will now see what radiology has done. Let us very briefly consider, too, the work of Moseley, who examined, and what is more important, interpreted the characteristic X-ray spectrum emitted by the atoms constituting various chemical elements. By the aid of X-rays behaving in the manner I have just indicated, Moseley was able to explore the very inner structure of these atoms. This examination resulted in his finding that the elements were related one to another in a very simple way. Imagine a long rack of numbered slots, the slots of which are consecutively numbered 1 to 92. Now every element was found to have its appointed slot, and the number to which it belongs *is the exact number of "active" or "excess" positive charges* which its nucleus holds and which govern the planetary or electron system. Carbon, for example, has six such positive charges, and its number (we call it its atomic number) is, therefore, six. Nitrogen has one more positive charge. Its slot or atomic number is, therefore, 7. Oxygen 8, and so on up to the very heavy atoms like uranium, which has 92 positive charges and whose atomic number is, therefore, 92. Now these atomic numbers are of the greatest possible consequence. They are very much more important and they convey very much more information about the properties of the element than its atomic weight does. The atomic weight, of course, for a very long time was regarded as being the sum of all knowledge about the atom. The atomic weight, by the way, is the *total* number of positive charges in the atom.

Certain slots in this row of 92 are not yet filled up, the elements not yet having been found, but when they are found we know that their atoms will have a certain definite number of "active" positive charges whatever may be their characteristics.

The theory of the atom which I have just outlined was based by Bohr on the energy hypothesis of Planck, whose definition of the relationship between frequency and energy went so very far in settling the long X-ray controversy; but the intimate investigation of the atom, and, therefore, of matter itself, is really a product of radiological research. Whither will it lead us? The prospect is indeed awe-inspiring. Will it enable us to analyse the electron as we have analysed the atom? Will it enable us to know what we mean when we talk of the ether? Will it, then, we may ask, ultimately lead us to understanding something of the nature of the Infinite? Is there a borderland between science and philosophy? or, perhaps, as I should say, between science and metaphysics? The metaphysician, as I imperfectly understand him, may "lie upon the daisies to discourse in novel phrases of his complicated turn of mind."

The scientist, on the other hand, contemplates his vacuum tube, which has cracked at a critical moment, perhaps for the 10th or even the 20th time. He remarks of the metaphysician, with perhaps some slight and surely very pardonable touch of asperity, "What *would* he do had he the motive and cue for passion that I have?"

AUSTRIAN AIR SERVICES.

Aviation in Austria, aided by the country's strategic central position and by the keen interest on the part of its general public, has developed rapidly during the last few years, writes the United States Consul at Vienna, and bids fair to maintain a greater activity in the future.

Several companies are operating regular air services from Austria to the principal

cities of Europe. The Compagnie Franco-Roumaine de Navigation Aérienne has established a route from Vienna to Prague and Paris and to Budapest and Constantinople. The Hungarian Air Traffic Co. operates between Vienna and Budapest. The Oesterreichische Luftverkehrs A. G. (Trans-Europe Union) operates between Vienna and Munich, connecting with a Munich-Zurich-Geneva line and with the Munich-Berlin line; it also operates a hydroplane service between Vienna and Budapest.

Austria has four landing fields, to and from which mail and passengers are transported by motor car—the Jedlesee and Aspern fields near Vienna, the Thalerhof field near Gras, and the Annabiehl field near Klagenfurt. The last three are controlled by the Federal ministry for commerce and traffic, but only the Aspern field is used to a large extent. The Jedlesee field, situated on the banks of the Danube, belongs to the Oesterreichische Luftverkehrs A. G.

Air traffic to and from Vienna during the first 10 months of 1923 accounted for 1,538 flights and carried 2,361 passengers and 46,720 kilos of mail and merchandise.

COFFEE PLAGUE IN BRAZIL.

Towards the end of May, 1924, it was announced that a plague had been discovered which was attacking the coffee-trees in the Campinas district, in the State of São Paulo. The plague or pest is ascribed to a minute beetle of the Stephanoderes type. The insect is known in other parts of the world.

The origin of the plague in Brazil, writes the Commercial Secretary to H.M. Embassy in Rio de Janeiro, is doubtful, but it is generally believed to be due to seeds and grafts imported from abroad for examination and analysis by various State authorities in São Paulo. Whether this is so or not, is not, however, definitely established, but the fact that such seeds were imported lends colour to the belief. The Campinas zone, in which the Agronomical Institute, to which these seeds were sent, is situated, is one of the oldest districts in Brazil in which coffee has been cultivated, and it is possible that the fact that the trees and soil are "tired" may have helped the propagation of the pest.

Both the Federal and São Paulo State Governments are acting in collaboration, through their respective Ministries of Agriculture, to combat the disease, and the former authority is also, in conjunction with other State Governments, taking steps to prevent the introduction of the plague into other hitherto unaffected regions.

So far, other large coffee-producing districts in São Paulo, viz., other than Campinas, are reported to be immune, but stringent measures are being taken to prevent any spread of the disease, which would be a calamity if São Paulo as a whole became affected.

Coffee is to be destroyed, if that is necessary, and the owners indemnified.

The outbreak of the revolution in São Paulo caused the general public to forget this subject, but São Paulo farmers and the public authorities are fully alive to the grave danger which may result both to the private farmer and to the Republic if efforts to stamp out this plague be relaxed for one instant. As at present constituted, the whole economic life of Brazil, especially in international trade, hinges on the coffee situation. Many Campinas farmers have suffered heavily.

For the first time in the history of Brazil the new north-west zone of São Paulo figures in the 1924-25 estimates at the head of the list of coffee-producing districts, and it is likely to maintain this position for many years to come. It is, in fact, thought that the extensive plantation which has recently taken place there and the annually increasing production of that region will not do more than compensate the gradually diminishing production of some of the older zones of São Paulo.

THE TRADE OF MONTHON MAHARAJ (SIAM).

The Monthon Maharaj comprises the three districts of Lampang, Phre, and Nan. The population is 530,000, and there are about 6,000 British subjects—Shans, Burmese, and Indians. Also there are about 30 European British subjects, for the most part engaged in the teak trade. Phre is the headquarters of the Administration, but is a town considerably less important than Nakawn Lampang (20,000 inhabitants), which is on the railway, and also the starting-point of the new arterial road to Chiengrai. Nan, an ancient town on the eastern side of the province, is decaying rapidly. Ngao and Payao, on the Lampang-Chiengrai road, are the only other important towns in Maharaj.

TRADE.—In his recent annual report on the trade of Monthon Maharaj, the acting British Vice-Consul at Nakawn Lampang states that although no statistics are obtainable, it is quite safe to say that trade during the year 1923-24 was bad. The reason is not hard to find. All trade is carried out on well-defined trade routes, viz., Bangkok-North, and trans-frontier trade with Burma and the Shan States. In the case of the former, merchants find that since the railway was completed it pays them better to send most of their goods through to Chiengmai, where a wider field awaits them; secondly, increased facilities by land and sea have encouraged the Burmese to resort to the southern route to Bangkok, and now the Lampang-Chiengrai road is cut the great caravans, which used annually to pour down from the Shan States and the Yunnan to Lampang, dispose of their goods there, and then perhaps carry fresh stocks over to Burma, stop at Chiengrai, and return to their own country. A good example of the effect of this, though unimportant in itself, is the absolute dearth of Shan ponies which used to come down in strings every cold season.

Again, there is no doubt that the severe slump in piece-goods experienced in Bangkok some three years ago has had a lingering effect on the markets in this Monthon. Money was heavily sunk in large stocks which are largely unsold to this day. Consequently the ordinary man has practically no ready money at his disposal; and when is added to this an unfortunate tendency to speculate in times of prosperity (and with Shan and Burmese British subjects to erect large and sumptuous temples often far beyond their means), it will be seen that credit conditions are exceedingly bad. In most of the towns to-day the bulk of the trade is in the hands of the Chinese.

Cloth Goods are mainly of British origin, although there is a Japanese factory in China which is supplying large quantities of inferior stuffs.

Hardware.—A great deal of this is German, obtained from a German firm in Bangkok, but articles such as tiffin carriers, soap dishes, and umbrellas are imported from Japan.

Bicycles.—It is a matter for congratulation that, notwithstanding the presence in Bangkok of an agency for extremely cheap Japanese bicycles, British machines are predominant in Lampang and Phre.

Motors.—Although at present the number of cars and lorries in this province is small, there is but little doubt that in the future there will be a larger demand. Already there is quite a fleet of lorries on the Lampang-Ngao road, and there is no reason why the Ford should hold a monopoly if a cheap British colonial model can be supplied. Last cold season even paddy was regularly brought by lorry into Lampang.

Teak.—Last year the rises in various rivers fluctuated so much that the timber brought down by the Me Wang was barely one-quarter of that of the Me Yome. In fact two prominent teak firm managers stated that their deliveries at the rafting station were about the worst, if not the worst, on record. In this connexion it is interesting to note that since the construction of a forest tramway through one of their forests they are able to transport thirty logs a day from their teak forest 36 miles away, over hills and creeks, and shoot them into the Me Yome at Pong, from which point the timber reaches Bangkok in approximately two years.

Silk Goods.—There is a small yet hardy industry carried on at Nan, where seins (skirts) and scarves are made mainly out of silk bought from Yunnanese and Shan traders. A small silkworm breeding industry is carried on in the valley of the Me Chune.

Cigarettes.—Despite extremely keen competition on the part of an efficient Chinese firm, there is a virtual monopoly of sale of cigarettes of a British firm.

COMMUNICATIONS.—Two important roads are under construction in this Monthon —the Lampang-Chiengrai and the Den Chai-Phre roads. The former is metalled most of the way to Ngao, but beyond that it is only built-up earth, which in the rainy season becomes a morass. When the road is finished motor traffic will be able to complete the journey to Chiengrai in 12 hours. The other work mentioned connects Phre with the nearest station on the railway, and although the ordinary road has been finished for some time, the Ministry of Communications is engaged in metalling it so that when completed, it will vie with any highway in the country.

PRODUCTION OF ALCOHOL FOR MOTOR FUEL IN THE TROPICS.

The question of making an efficient motor fuel in the tropics, where imported spirit is expensive, is at present attracting considerable attention. Various materials have been suggested, and in some cases tried, as a source of power alcohol, such as starch-containing roots, and cellulosic residues from the sugar and other industries, but one of the most valuable appears to be the sap which may be collected from the flowering shoots of the Nipa palm of the Far East. Considerable work has been done in the Philippine Islands in ascertaining the suitability of this palm for the production of alcohol and quite recently an experimental plant has been erected in the State of North Borneo. An account of the results of the first year's working, based on a memorandum supplied by the British North Borneo Company, is given in the current number of the "Bulletin of the Imperial Institute."

There are about 300,000 acres of nipa palm in North Borneo, occurring in nearly solid stands of 5,000 acres or more. The sap flows for only six months in the year, but it is estimated that during this period 900,000,000 gallons of sap, capable of producing nearly 60,000,000 gallons of alcohol, could be obtained. The results of the first year's working of the experimental plant came up to expectations in every way. The still was only capable of producing 100 gallons of alcohol per working day of 12 hours, and the costs of running such a small plant were naturally somewhat high, but it is shown that a permanent plant producing not less than 1,000 gallons per day should prove a commercial success. Estimates are quoted in the article of the cost of production for plants of various capacities. For a plant capable of producing 2,000 gallons per day of 12 hours the capital required is estimated at about £26,000, and the profits on the spirit delivered in Singapore or Hong Kong would be equivalent to a dividend of 10 per cent. on the capital. An 8,000 gallon plant run for 24 hours per day would require a capital of about £122,000, and this, it is estimated, would yield profits equivalent to 30 per cent. on the capital.

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PROCEEDINGS OF THE SOCIETY.

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CANTOR LECTURES.

RADIOLOGICAL RESEARCH—A HISTORY.

BY V. E. PULLIN,

Director, Radiological Research Department, Woolwich.

LECTURE II.—*Delivered 26th January,* 1925.

We have now seen the theory of X-rays developed and the enormous amount of work that was done before our ideas on the subject were clear, and next we will endeavour to trace the development of apparatus, but as the time at my disposal is so short, I shall be forced to treat the subject in a somewhat sketchy manner and to refer to the emergence of important principles rather than attempt any detailed reference to the many interesting modifications of X-ray apparatus which were made and worked by so many investigators. Furthermore, if there is time, I am anxious to direct your attention to the lines upon which X-ray apparatus is at present being improved. I wish to beg the indulgence of these X-ray pioneers who are still happily with us. I must, of course, refer to their work, and I shall endeavour to be as accurate as I can, but some mistakes will certainly occur, particularly with regard to priority of work in the congested time of early 1896, and I can only express my good intentions, and, as I proceed on my way, beg them to forgive me for my errors.

X-rays are essentially a vacuum phenomenon, and, consequently, X-ray research may be said to have started with the " discovery " of vacuum by Galileo's brilliant secretary Torricelli in 1643.

The idea of vacuum would appear to have always been a most fascinating theme. The first atomic theory of Democritus was a development of the two ideas Plenum and Vacuum, and ever since it is a question which has occupied the great thinkers of every age. Even now, in spite of our experimental experience and resource, and in spite of that very simple, yet classical, definition by the school boy—you will remember his definition of a vacuum—"A large open space in which the Pope lives"!—in spite of these things the obtaining of a suitable vacuum in an X-ray tube is one of the outstanding problems of modern physics.

After Torricelli, about seven years afterwards, Von Guericke gave us the first mechanical air pump—a long narrow tube fitted with a plunger and two valves. It is worked on the principle of the common suction pump. Subsequently there were others, but, in spite of these efforts, the Torricelli method of producing a vacuum remained in use for 200 years.

It is an interesting fact that as late as 1845 a patent was taken out in which the method was used for producing a vacuum in an incandescent electric lamp. The later vacuum pump of most noticeable importance was, of course, the Toepler pump invented about 1862, and it is even now in fairly general use. It was used by all the X-ray pioneers.

Concurrently, of course, with the development of vacuum apparatus, electrical work was progressing, and we must observe the growth of them both if we are to see where they join forces to produce our X-rays.

Otto Von Guericke not only produced the first vacuum pump, but he also invented the first electrical machine, which consisted of a sulphur ball, which was rotated on a spindle and rubbed with dry hands.

As a result of his work on these lines, he discovered that electricity would repel as well as attract, and also would yield sparks.

Soon afterwards, Sir Isaac Newton improved Von Guericke's machine by substituting a glass for the sulphur ball, and afterwards a rubber was provided instead of using the hands. This was about the condition of affairs when we arrive at the year 1705, so important to our subject.

I will show you pictures of some of these early electrical generators.

Now in 1705, Mr. Hawksbee, F.R.S., discovered what is called his mercurial phosphorus apparatus. He found that by agitating mercury in a vacuum he obtained a glow. The first electric discharge in vacuo! He thought this glow was a property of the mercury, hence the name he gave it. He adopted several methods of agitating his mercury and obtained the same result every time. He tried the experiment also in a non-exhausted bulb and observed small sparks, but no glow. Some time afterwards Mr. Hawksbee, still investigating the properties of vacua, conceived the idea of rubbing different substances together in a vacuum, this time, of course, with the definite intention of investigating electrical phenomena. He arranged a mechanical device by which he could rub amber beads and wool together in an evacuated jar.

He observed a glow. He next tried glass and wool and obtained what he describes as " a fine purple light," and he says, " upon letting in a little air, both the light and colour did diminish."

By the courtesy of the Royal Society I am able to show you illustrations of these classical experiments.

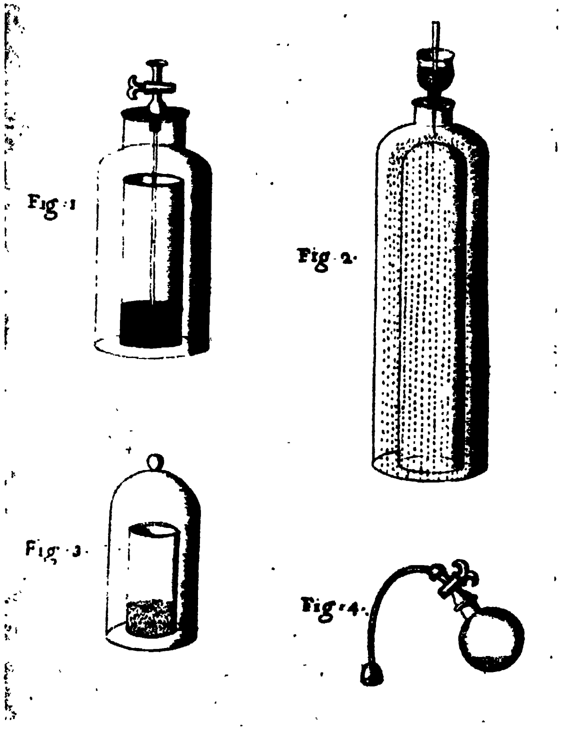

FIG. 1.

Hawksbee's Apparatus, "Mercurial Phosphorus," 1705.
(*By courtesy of the Royal Society*).

The next development of interest is contained in the observations of the Abbé Nollet, in Paris, published in 1740. This gentleman appears to have been interested in Hawksbee's results and to have carried his investigations a little further. He used an electric machine and pump and connected his electrical machine to his vacuum by means of a chain and obtained very striking results. He demonstrated that electrification was possible in a vacuum.

Slides 7 and 8 are reproduced from his records in the Royal Society. Incidentally another very interesting point which illustrates the prevalence of empirical observation at this time is described by Nollet in 1763. It is a novel form of electric generator. These observations are not original, but

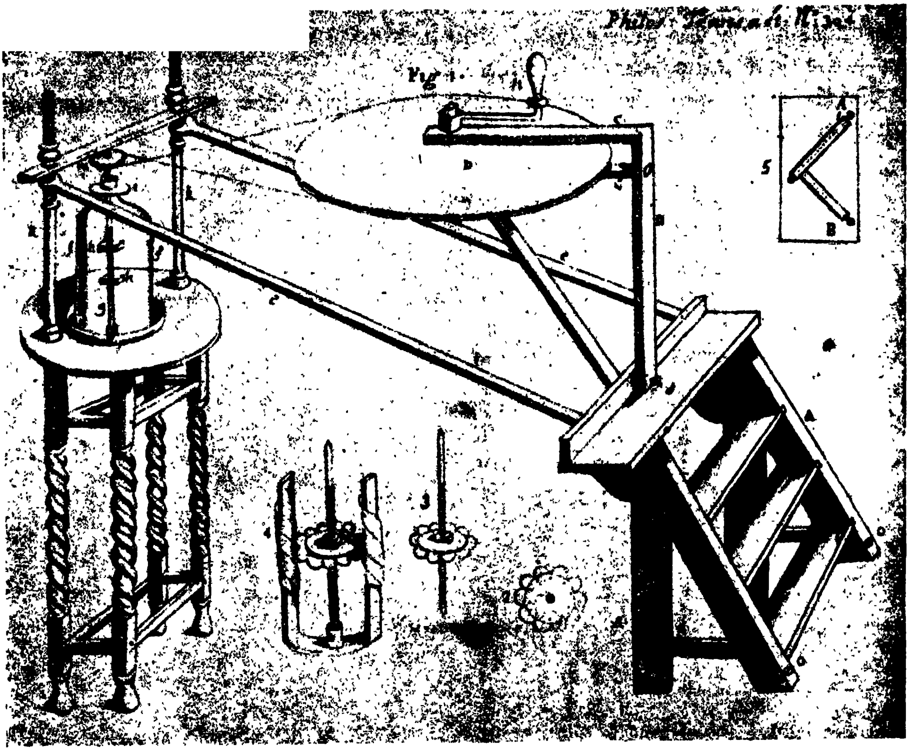

FIG. II.

Hawksbee's Apparatus, "Attrition" Apparatus.

(*By courtesy of the Royal Society, Phil. Trans.*, 1705).

are due to a Mr. Symmer, who, in 1759, observed that his stockings had a tendency to fly together when he took them off, but only when he was wearing stockings of different materials. He observed the same thing with a black and a white silk stocking, but not with two blacks or two whites. He observed this phenomena because he happened to be in mourning and wore a black stocking over a thin white one. Mr. Symmer was so impressed that he communicated several papers to the Royal Society on this subject.

In 1785, a Mr. William Morgan conducted certain experiments which are of the greatest importance in the history of Radiological Research. His idea was to investigate the possibility of passing an electric discharge through a vacuum. His results are most interesting to us. In the first place by suitably preparing his apparatus—he tells is that he boiled his apparatus, and he also boiled his mercury in a "special manner"—Mr. Morgan obtained in 1785 what we now know as a "Coolidge" vacuum. He found that it was impossible to pass his electric discharge. He proceeded with these investigations, and on allowing a little air to enter he observed a *green fluorescence.* Mr. Morgan was undoubtedly producing electronic bombardment, and consequently, X-rays, and was very probably the first experimenter to do so. He goes on to record the fact that he could estimate the degree of vacuum he obtained by means of the colour of the glow when a discharge was passed.

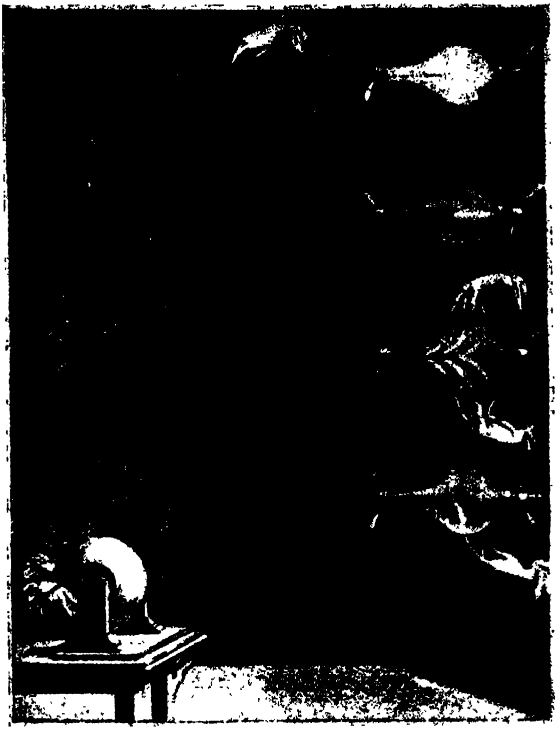

FIG. III.

Abbé Nollet's Apparatus. Electric Discharge in Vacuo (1740).

(*By courtesy of the Royal Society*).

In 1831, we have one of the most striking discoveries of modern times—I refer, of course, to Faraday's induction apparatus—the transformer and induction coil to which radiology owes so much.

By the kindness of Sir Wm. Bragg, I am able to show you a slide of Faraday's original apparatus.

This discovery, of course, stimulated work on electrical lines. Electrical conductors and non-conductors had already been discovered in 1729 by Steven Gray, and the process of electrification by induction had been discovered in about 1760 by John Canton, which led to influence machines, and finally the Wimshurst electrical machine.

Just previous to Faraday's discovery, Dr. G. S. Ohm had introduced the modern ideas of current and electro-motive force resulting in the enunciation of his famous law.

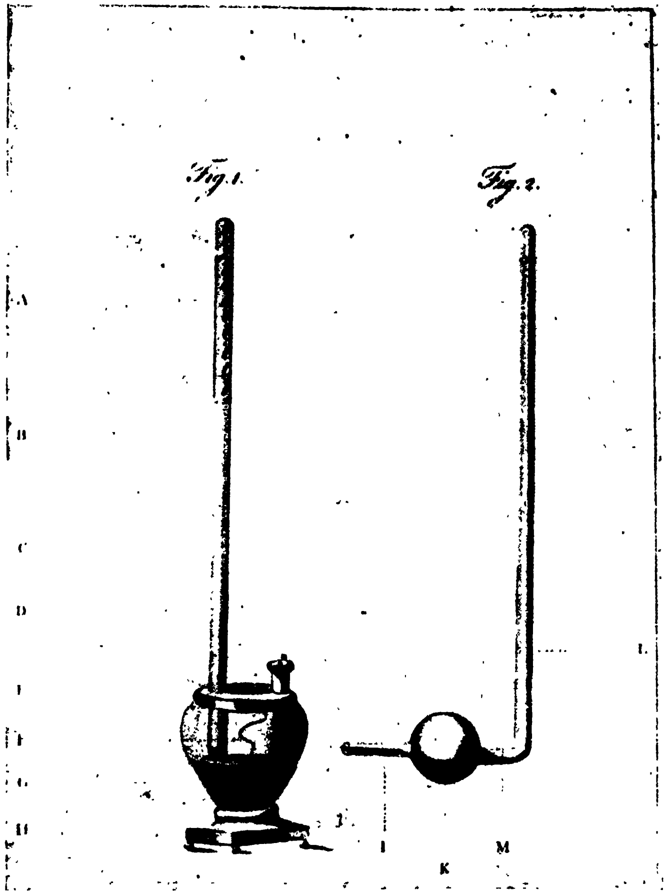

Fig. IV.

Mr. Morgan's Apparatus.

(By courtesy of the Royal Society, Phil. Trans., 1785).

Faraday's work very soon resulted in the appearance of other induction coils, interrupters and so on. I will show you an illustration of an induction coil and interrupter of Bachhoffner of about 1837, and also an interrupter of Sturgeon's of 1838.

Another curious H.T. generator might be mentioned here, again illustrating empirical observation and its results.

In 1840 Armstrong wrote to Faraday to tell him of an extraordinary electrical phenomenon of which he had been informed. It appeared that a leakage of steam had occurred from a steam engine boiler and the whole boiler was found to be electrified sufficiently to give a definite spark and shock. This phenomenon was investigated by Armstrong in the succeeding years to 1843, with the result that he constructed his hydro-electric machine. It is said that the spark from the machine was 22 inches in length.

Faraday found that the electrification was caused by the friction of the water particles against the nozzle and not to evaporation which was suggested by Armstrong.

One of these machines is to be found in the Science Museum at South Kensington. Now, as far as electrical development w [illegible] verything was ready for the discovery of Cathode rays.

We will now take up the story of the development of electric discharges in vacuo at the point where Mr. Wm. Morgan had made such marked progress. Incidentally I want you to notice how experiment is tending to advance from the almost purely empirical observations of Hawksbee, for example, to Morgan who experimented with the idea of verifying a definite hypothesis.

Humphry Davy, and then Faraday, investigated the subject, and Faraday of course, observed the dark space round the cathode, which directly led to Hittorf's discovery of his straight line negative glow light, in other words, the Cathode stream. It is of interest to note that Hittorf observed that the shape of his tubes and the deposition of the electrodes had a very marked effect on their electrical resistance; a rather remarkable forecast of that piece of apparatus now so much used and known as the valve tube. Hittorf's advance was largely due to the much improved apparatus now available. It was now 1869. He used a Rhumkorf coil and condenser and an improved form of Toepler pump due to Dr. Geissler. He was consequently able to work with much better vacua than the earlier workers. Then came Crookes, who told us practically everything about the Cathode stream. As we have already seen he was only wrong about its constitution.

Crookes found that the degree of vacuum necessary to produce fluorescence in his bulbs was, roughly, one millionth of an atmosphere, or .00076 mm. Hg. We call that *one bar.* We might note that the degree of vacuum in a modern X-ray (Coolidge) tube is about one hundred times better than this. Crookes made tubes of various shapes and designs in order to demonstrate the various properties of his "radiant matter." Perhaps the greatest interest in the Crookes tube was the ability of the Cathode stream to cause certain substances to fluoresce, and so to produce the most striking and beautiful results.

All of these Crookes' tubes must have been producing large quantities of unrecognised X-rays. One of the most striking facts about the discovery of X-rays was its semi-accidental character. Very many investigators must have been on the very verge of the great discovery. Sir Herbert Jackson, for example, was experimenting with Crookes' tubes in order to discover materials, the phosphorescence from which might consist only of ultra violet radiation. In the course of his work, he noticed that certain objects *outside* his tubes were emitting visible light. Of course, he was very much impressed by this phenomenon, and concluded that the effect was due to short wave lengths emitted by the mineral ores which were inside the tube. He repeated the experiments with an aluminium window in his tube, and the results were intensified; and in his own words, "Just when I was puzzling over this, Röntgen's discovery was published, and I saw the explanation of my own results."

Röntgen's discovery was actually due to his use of a fluorescent screen of barium platino-cyanide, which was a material in very general use. Röntgen describes how he observed this material to fluoresce when in the vicinity of a Crookes' tube, which he was operating by means of an induction coil. He says that this radiation will penetrate card, wood, etc. Even a sheet of aluminium 15 millimeters thick still allowed the rays to pass.

The first published records of X-ray experiments in this country are by Mr. Campbell Swinton, and I shall refer to them in my next lecture. Mr. Campbell Swinton was very early in the field with modified apparatus. In most of the experiments with Crookes' tubes it had been desirable to demonstrate the generation of heat, but now heat, which cracked the glass, was to be avoided, and to this end Mr. Campbell Swinton stuck a piece of platinum foil on the glass of his tube, on the spot on which the Cathode rays would impinge. This was very probably the first use of platinum as the target of X-ray tube.

Sir Herbert Jackson immediately experimented with the new rays and tried bulbs of various shapes, and he very soon convinced himself that the best shape and design for an X-ray tube was a spherical bulb fitted with a concave cathode to focus the cathode stream. Sir Herbert Jackson has yet to be proved wrong—for this is the standard shape at the present time!

I will now show you some slides of early X-ray tubes. I cannot show you Sir Herbert Jackson's original tube because it does not exist. Sir Herbert tells me that he has heard of bulbs being shown and referred to as his first bulb, but they are not authentic, as the first bulb was, most unfortunately, broken.

Sir Herbert Jackson also experimented, in 1896, with many different metals as the targets of X-ray tubes. Prof. S. P. Thompson pointed out that metals of high atomic weight would be the best emitters of X-rays, and, in point of fact, in June, 1896, Sir Wm. Crookes had used metallic uranium as a target, but gave it up owing to the difficulty in obtaining the metal. In 1898, however, osmium target tubes were actually on the market.

The following are some early forms of X-ray tubes and serve to illustrate the rapidity with which the salient features of the X-ray tube, as we know it now, were developed.

In March, 1896, Mr. Campbell Swinton introduced an X-ray tube having two cathodes intended for use with alternating currents. In June Sir Oliver Lodge introduced the all metal X-ray tube—an early recognition of a pressing need which has not yet been adequately met.

Towards the end of 1896 we had the heavy anode tube, due again to Mr Campbell Swinton, and early in 1897 he gave us an X-ray tube with adjustable electrodes. In 1898, I think, we had the first automatic regulator X-ray tube.

Another early development of this subject is not without interest. You will remember that the discovery of X-rays was brought about by the fluorescence of barium platino-cyanide salts. This is, of course, the double salt which is used in the fluorescent screens in modern use. Such screens were in use from the very first, though some of them were of potassium platino-cyanide. Edison sent the following very optimistic telegram to Lord Kelvin early in March, 1896. " Just found calcium tungstate properly crystallised gives splendid fluorescence with Röntgen rays—far exceeding platino-cyanide—rendering photographs unnecessary."

As early as January 30th, 1896, Mr. Campbell Swinton had suggested at University College that a fluorescent material should be used, either as a photographic screen, or incorporated with the photographic emulsion in order to shorten exposures. He went on to say that he had experimented with both methods. Other writers put forward the same idea.

J. W. Gifford, in about April of this year, records his use of the same method, but using a potassium platino-cyanide screen. It would appear that the reason for these screens dropping out of general use for so long was the difficulty of eliminating the grain—a trouble which has not yet been entirely overcome. Another and rather surprising point of interest is that " Two screen " technique and double-sided films were used in X-ray work as early as 1897. Dr. Max Levy says that by employing this technique he was able to shorten exposures from 12 to 15 times. (In practice it is only possible to obtain a reduction in exposure from, say, 25 to 20 times with modern technique.) Other workers record similar results.

In 1897, also, our somewhat modern practice of using sheets of lead as intensifier screens for hard radiation had been anticipated. Bignet draws attention in 1897 to the advantage of putting lead behind the photographic plate and also of covering the sides of the object in order to eliminate blurring of detail by scattered radiation.

One thousand nine hundred-and-thirteen was a red-letter year for X-rays, for in that year Dr. W. D. Coolidge introduced the first hot Cathode X-ray tube—whereas previous X-ray tubes depended for their action upon the ionization of some residual gas by an electric discharge for the production of the cathode stream. The new tube produced the electron stream by evaporation of electrons from an electrically-heated tungsten filament. The new tube operated at saturation current and so the voltage and the current were adjustable and controllable independently, which alone gave it an enormous advantage over the old "gas" tubes.

The principle of the Coolidge tube, of course, was based on the work of Fleming, Richardson, and others on the emission of electrons from hot bodies and the adaptation of this phenomenon in the construction of electrical valve tubes, but the application of this principle to an X-ray tube was made possible by the valuable work in Dr. W. D. Coolidge's new method of working that very refractory metal tungsten, which he described in 1912.

The largest commercially available Coolidge tube is rated at 200,000 volts, and it is the tube which is employed in heavy industrial radiography.

Let us now consider the present position and try to understand exactly what modern research on apparatus is aiming at. I intend to exclude all reference to that highly important aspect of the subject—its medical applications.

1. We will first decide what we want X-rays to do.
2. Then we will see what apparatus we have at present and whether it will do it.
3. Then we must determine what apparatus we want and whether we shall be able to get it.

What do we want X-rays to do?

We want radiology to be *the indispensable adjunct* to all engineering practice. That will do for the moment.

X-rays enable us to examine the interior of materials without in any way damaging or destroying them. This is a fundamental fact of the greatest importance. Let us consider steel castings for all manner of purposes. After the casting is made a great deal of money and time is spent in machining and preparing it for its final use. If the casting has flaws in it they may only become apparent after a great deal of expensive work has been done on the casting. On the other hand, they may not be discovered and remain a hidden source of danger. Now X-rays enable us to examine the inside of such castings *before* work is done on them, but only in the case of comparatively small castings at present. The expense involved in machining castings is very much more for larger castings than small ones, therefore we want X-rays to enable us to examine very large masses of steel, say, up to 8, 10 or even 12 inches in thickness. We also want such examinations to be practical and safe. That will do for the moment as to what we want X-rays to do.

Now what apparatus have we got? We have to consider two types of apparatus: the electrical generator and the X-ray tube. The thickness of steel, which is penetrable by X-rays is very largely governed by the voltage, which we are able to apply to the terminals of the X-ray tube—for reasons which I shall refer to in a moment, we are more or less confined at present to electrical transformers yielding about 200,000 volts, and this is not enough. This voltage will only allow us to penetrate about three inches of steel. Of course, we use it, but such examination has nothing like the money saving value it would have if we could penetrate eight inches of steel.

So we have tried to produce higher voltages. This is a problem that has involved much study of questions of transformer design, insulation and so on.

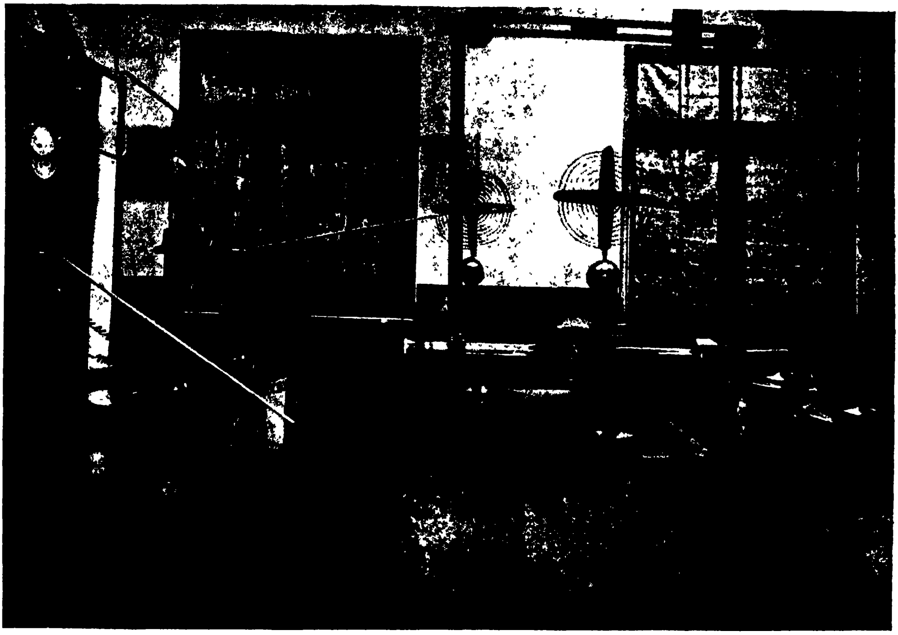

Fig. V.

400,000 volt. X-Ray Installation,
Radiological Laboratory, Research Department, Woolwich.

The illustration shows a transformer designed and constructed in my department which is rated at 400,000 volts.

It is essential in the production of X-rays that the current should pass in one direction through the X-ray tube, and as this transformer supplies current first one way and then the other, we have to adopt some method of inducing both halves of the current to proceed in one direction and the next slide shows the methods most generally in use.

(A description with illustrations was given of the usual methods of rotating disc rectification, and also rectification by means of hot cathode valve tubes.)

You will see from these diagrams that, from an X-ray point of view, this machine is a very inefficient generator of X-rays. Therefore, at present our research is towards a better one. So much for X-ray generators.

Now we will consider what we have at present in the way of X-ray tubes. I have said that the type of tube generally used in industrial practice is the large type Coolidge tube, whose maximum voltage is 200,000. If you attempt to give it any more it breaks. Sometimes even these tubes get nervous and break before they get as far as 200,000. At the same time this is the very best tube that can be bought at present. Therefore, you see the limiting penetrable thickness of steel is defined very largely by the X-ray tube. We have just seen that we have a generator that will give us 400,000 volts. If we had a tube that would take this voltage we should probably be able to penetrate eight inches of steel. Then it is the development of the tube which must occupy the chief place in radiological research.

There are several very important factors involved when we come to consider the production of tubes for extremely high voltages. Our old friend the vacuum turns up again in a very difficult mood, and he is the chief obstructionist. The higher we go in voltage the better must be the vacuum in our X-ray tube. Every scrap of gas must be pumped out, not only out of the bulb, but also every particle which is lurking among the molecules of the metal electrodes and the glass walls.

This problem must not be confused with that of merely obtaining, or even of obtaining and maintaining, a very high vacuum. In the course of pumping out the gas, ionization occurs which results in isolated streams of positive and negative charges roaming about in the tube and manifesting their presence by cracking the glass in the most unlooked for places and at the most inopportune moments.

Our chief problem is so to design the tube that these inevitable stray charges shall be under some sort of control, even when a powerful disturbing element like three or four hundred thousand volts is brought into contact with the tube.

These problems have not yet been solved, but they are well under way, and a large amount of information has been acquired concerning the conditions in which these stray charges are influenced.

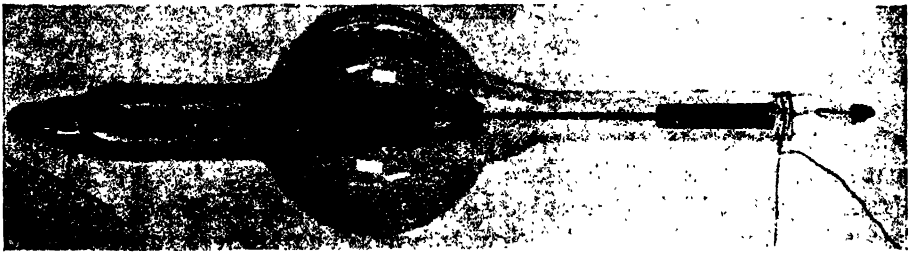

FIG. VI.

Hooded Anode Tube (Radiological Laboratory, Woolwich).

The next slide illustrates a new type of X-ray tube which is designed to control to some extent the formation of positive ions in places where they do considerable damage to a tube operating at very high voltage, and the principle involved will probably be of considerable value in the production of a very high voltage tube.

I will show you some modern experimental types of X-ray tubes which have been experimented with in my laboratory.

A very important feature of hot cathode X-ray tubes is the device employed to focus the cathode stream. It is desirable that the output of X-radiation shall be from one particular spot on the target—the focal spot. The method adopted in the standard Coolidge tube is shown in the next slide.

You will see from the last slide that X-rays proceed not only from the focal spot, but from all parts of the target.

I will now show you another type of cathode which has been designed by my colleague, Mr. C. Croxson, which constitutes a very great improvement.

From the last picture you will see that the radiation from parts of the target other than the focal spot has been enormously cut down. In the Coolidge tube the radiation from these other parts is estimated at one-sixth of that from the focal spot. With the improved cathode it is only one-fiftieth of the amount. This is a most important point in tube design, and is based on an entirely different method of controlling the disposition of the cathode stream.

We have now seen something of the way in which X-ray apparatus has developed. We have seen that there is a demand for very wide X-ray applications involving complicated and powerful apparatus. There is no question whatever but that we shall satisfy these demands. Nothing but the highest possible degree of skill, combined with infinite patience sustained through reiterated failure, will achieve success; and surely a most cursory study of the labours of those who have gone before, a rapid review of their failure and their most brilliant successes, must provide the very best and noblest stimulus to those of us who are giving our lives to the triumphant vindication of all that we claim for our specialised branch of physics.

THE INFLUENCE OF THE MOTOR SHIP ON EXPORT TRADE.

The spectacular happenings of the war and post-war periods have tended to obscure a silent revolution in shipping which has been going on in the last 15—and especially in the last five years. The exporter has been so absorbed with the dramatic boom in 1919, the sudden collapse in 1920, and the slow and painful recovery of trade in the last four years, that he has given little thought to the details of shipping. He has been conscious only of the severity of competition abroad and the high expenses at home. He has even been inclined to say that high ocean freight rates are keeping him out of desirable markets, when, as a matter of fact, the decline in ocean rates has been greater than the decline in prices.

Unseen, except by the careful observer, says the official United States "Commerce Reports," a force that should cause world trade to increase has been at work.

This force is the motor ship, which, by reducing the cost of carriage by sea, is stimulating oversea trade.

The term "motor ship" has come to be applied to a vessel equipped with Diesel engines for propulsion. A Diesel engine is an internal-combustion motor, as opposed to a steam-power engine in which coal or oil is burned under boilers to make steam. In a Diesel motor crude oil is forced under great pressure into a cylinder in which the air is compressed to about 500 pounds per square inch. The resultant temperature within the cylinder is so high that combustion results immediately when the oil is forced in. This combustion causes expansion; in other words, produces power.

The first small seagoing motor ship was constructed in 1910, and the first large one in 1912. Since that time, in spite of the fact that four war years have intervened in which construction was limited largely to standard designs of steamers, motor-ship tonnage has increased to 1,700,000 gross tons. Of all the ships under construction in the world to-day, more than one-third are to be equipped with Diesel engines. This large amount of motor-ship tonnage in active employment has a distinct tendency to keep ocean rates down.

The most recent development in motor-ship construction is in the field of the large passenger ship. Hitherto only cargo boats and small passenger-cargo ships have been equipped with Diesel engines; but in the past year two passenger ships, averaging around 20,000 gross tons each, have been ordered and are now nearly completed.

Necessarily, engine designs have had to be changed to develop the enormous power for driving a 20,000-ton ship at a speed of 17 knots. The double-acting type (with an impulse or each side of the piston) has been successfully designed and constructed. While large power installations for high speeds are not entirely faultless, it is reasonable to assume that the Diesel engine has made an entry into the most difficult marine field, the express passenger service in the north Atlantic.

The motor ship in general is to-day the most efficient ocean transportation unit. Although a new motor ship costs approximately 25 per cent. more than a steamer of similar size, it can carry goods from 10 to 30 per cent. cheaper. These economies are due to several factors. A Diesel-engine installation takes up much less space than a steam plant, thereby allowing more cargo to be carried. A Diesel engine consumes much less fuel than other types. In general, 0.43 pound of fuel is required to produce one brake horsepower hour in a Diesel engine, as compared with 0.90 pound for an oil-burning steamer and 1.25 for a coal burner. It takes a smaller crew to run a motor ship than to run a steamer. No coal passers or trimmers are needed on a motor ship, nor are so many oilers required. There are numerous smaller advantages which also contribute to the unquestioned economies of motor-ship operation.

Considerable interest in motor ships has been shown by American shipping companies, and a number of vessels of this type have been built for private American shipowners. All the leading shipyards in the United States have developed types of marine Diesel engines or are building them under license from leading European companies. Congress recently appropriated $25,000,000 to enable the United States Shipping Board to convert about 50 of its better-class steamers to Diesel propulsion.

In the near future, concludes "Commerce Reports," the trade of the world will indubitably tend to increase more rapidly, because the motor ship is cheapening the cost of ocean transport as surely as the steamer did in the eighties of the past century.

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PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

RADIOLOGICAL RESEARCH—A HISTORY.

BY V. E. PULLIN,

Director, Radiological Research Department, Woolwich.

LECTURE III.—*Delivered 2nd February,* 1925.

Röntgen's discovery of X-rays was first announced in this country by a telegram from Vienna published in the *Standard* newspaper on January 6th, 1896. It was called a *photographic* discovery—and the practical importance of the new discovery to surgery was pointed out. The telegram concluded:—"The 'Presse' (Vienna) assures its readers that there is no joke or humbug in the matter. It is a serious discovery by a serious German Professor."

On January the 7th, 1896, Mr. Campbell Swinton took what were probably the first X-ray photographs in this country. His first experiment was to radiograph a piece of aluminium upon which, half-way through the exposure, he put a penny, and, when the plate was developed, the penny was visible. On this day he also took a photograph of a hand, and the exposure was about 20 minutes.

Fig. VII. is the radiograph he obtained. It is interesting to compare this radiograph, remembering the time of exposure, with one taken the other day in the Radiological Laboratory at Woolwich the exposure for which was a *practically* immeasurable fraction of a second, a mere flick!

The following slides are all pictures taken by Mr. Campbell Swinton during the first few days after the discovery was announced. Fig. VIII. is a picture obtained in January, 1896, by my father in his private laboratory.

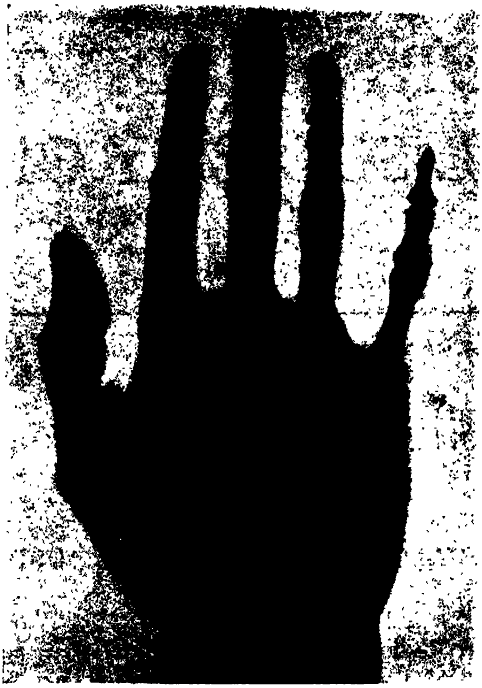

FIG. VII.

First X-Ray Picture taken in England, Jan., 1896, by Mr. A. A. Campbell Swinton, F.R.S.

Mr. Campbell Swinton pointed out that he got much better results with a high frequency electrical supply than with an induction coil. This, of course, was due to the fact that the early tubes were not constructed to carry the heavy discharge of an induction coil. He also stated as early as the beginning of February that in order to shorten exposures, high voltage and high vacua were necessary. He obtained at this time a very successful radiograph of a foot, with a 55 second exposure using a 10-inch spark induction coil working at "about half power," and in April, 1896, Dr. John Macintyre succeeded in obtaining a very good radiograph of fingers with a single flash exposure.

Concerning early applications of this new radiation the remarkable thing is that all or very nearly all of our much vaunted modern applications were certainly suggested, if not actually used, in the very early days. A very early non-medical application was told me the other day by Sir Richard Gregory. It appears that one or two days after the announcement in the *Standard*, Professor Sir H. Jackson invited Sir Richard and some other friends to visit his laboratory to witness some experiments with the new X-rays. On the way Sir Richard Gregory called at a shop and bought an umbrella; he insisted upon having one in which the handle and the stick were all one. In spite of

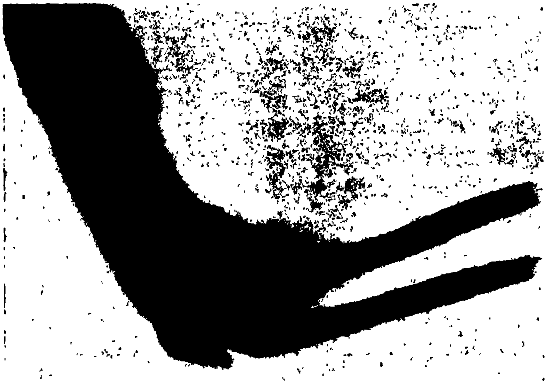

Fig. VIII.
Radiograph of Arm taken Jan., 1896, by Pullin.

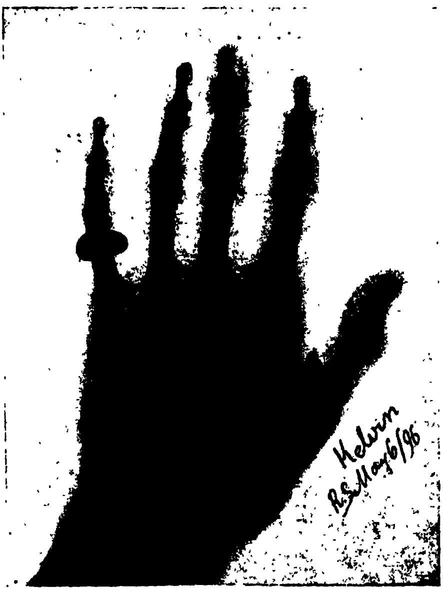

Fig. IX.
Radiograph of Lord Kelvin's Hand.
Taken early in 1896 by Mr. A. A. Campbell Swinton, F.R.S.

solemn assurances that the article purchased strictly complied with his requirements, Sir Richard was a little sceptical, and he at once made use of the new rays to test the truth of the shopman's assertion. Sir Herbert Jackson examined the umbrella with a fluorescent screen, and, lo! the shopman was untruthful! The stick was clearly screwed into the handle! One can imagine the consternation when Sir Richard took back the umbrella. This was probably the first "industrial" application of X-rays.

The value of X-rays to surgery was, of course, immediately recognised. Professor Röntgen was at once honoured by the Emperor. The Prussian Minister of War caused experiments to be made in order to discover whether the method could be successfully applied to military surgery.

Incidentally the contrast between German and our own more conservative methods is illustrated by the fact that some *eighteen months* after the above incident, a question was asked in our Parliament as to the supply of X-ray apparatus for the Soudan campaign. The reply, I believe, was that the S.M.O. could trace no case in Egypt where such apparatus would have been specially useful!

Four days after the news of the discovery had been received in America a letter was received describing the use of X-rays to examine a patient with a bullet in the calf of his leg. It says 40 minutes' exposure produced a photograph showing the tibia and fibula . . . . and the flattened bullet lying between the two up against the inner angle of the tibia. Next day the bullet was extracted with a *two-inch* incision, although the bullet was *five inches* remote from the entrance wound.

During 1896 all manner of medical applications were used not only to show the position of foreign bodies and fractures, but the rays had been used as an aid to diagnosis of tuberculosis, heart disease, bone disease and also to locate such things as a bullet in the brain, and a needle in the tonsil. Treatment by X-rays had also been tried for tuberculosis and cancer, and improvements in cancer cases had been reported.

So wide and varied were the applications that in May, 1896, five months after the discovery, the first British periodical devoted to X-ray matters appeared—"The Archives of Skiagraphy." *The British Journal of Dental Science*, in April, 1896, quotes a report to the effect that a dentist has applied X-rays in his profession. It states that the results are most delightful. Toothache is a thing of the past! It was an American dentist!

In 1897 the same Journal records that by means of X-rays a patient at University College Hospital was relieved of his anxiety that he had swallowed his false teeth. He went happily home to look for them.

The next slide shows a very remarkable radiograph taken a few months only after Röntgen's discovery.

The next, a still more remarkable picture—A full-length radiograph of a woman completely clothed. Dr. W. J. Morton, who took this wonderful picture in the early months of 1897, remarks that he particularly chose a well-formed and well-nourished woman for the experiment—in order, no doubt, to make it harder! The film, 5ft. long by 3ft. wide, was specially made for the experiment.

Industrial uses for X-rays have recently come very much to the fore, and, as I shall show, are now being very widely adopted, but the very early references to industrial applications are extremely interesting. Quite recently it was brought to my notice that what appeared to be the very last word in X-ray applications was the examination of coal for impurities and quality. It is, therefore, somewhat surprising to find that this work was actually in progress before July, 1897, and in 1898 the method was apparently in general use in France.

One month after the discovery of X-rays they were used in America to examine a metallic weld—a piece of metal which had been welded, but showed no flaw or line of fracture. The X-rays however, revealed the fracture. This result was regarded as highly important by the Ordnance Officials as a future means of testing armour for hidden defects.

In 1896 X-rays had been used for the detection of food adulteration. They had also been used in experiments to discover whether they had any germicidal action, and by the middle of 1897 they had been used :—

For the discrimination between real and artificial gems.
For the detection of the contents of parcel post packages.
For the detection of flaws in welds.
For the detection of contraband in baggage.
To examine insulation in cable making.
To examine the interior of bombs.
To examine the properties of alloys.

And late in 1897 they had been used in the investigation of potatoes, the X-ray density of which was found to increase as the potato is richer in *fécula.*

They were also used to detect impurities in baking powder—this was in America !

In 1898 Röntgen reported that under rather exceptional conditions he had managed to penetrate *one-six* inches of iron !

In 1904 it was reported that X-rays were used to detect pearls in pearl oysters without opening the shell or injuring the mollusc in any way. The process was said to save much time.

In 1899 an American enthusiast patented a process of manifold printing by X-rays. Many sheets of sensitized paper were piled up with the copy on the top, which was written or printed with a " metallic " ink ; the whole was X-rayed and copies made. It must have been an expensive business, apart from the initial cost of the kinetoskotoscope, as, I think, it was called.

You will observe that in the first year or so the number of applications was really very remarkable. Most of these applications, however, dropped out of use, chiefly because X-ray apparatus was scarce and expensive, technique was, perhaps, a little strange, and also there was the bogey of X-ray disease which very soon became so prevalent.

X-rays have claimed a lamentably long list of martyrs, but happily, owing to our advanced knowledge, we are able now to design installations which are safe, and, therefore, future harm need not appear to any great extent.

The first suggestion of the harmful effect of X-rays appears to have come from Edison, who reported that both he and Dr. W. J. Morten suffered from sore eyes for some hours after the work with X-ray tubes.

Very early in 1896, however, other bad reports were received. A correspondent of "Nature," in October, 1896, describes a severe dermatitis of the hand.

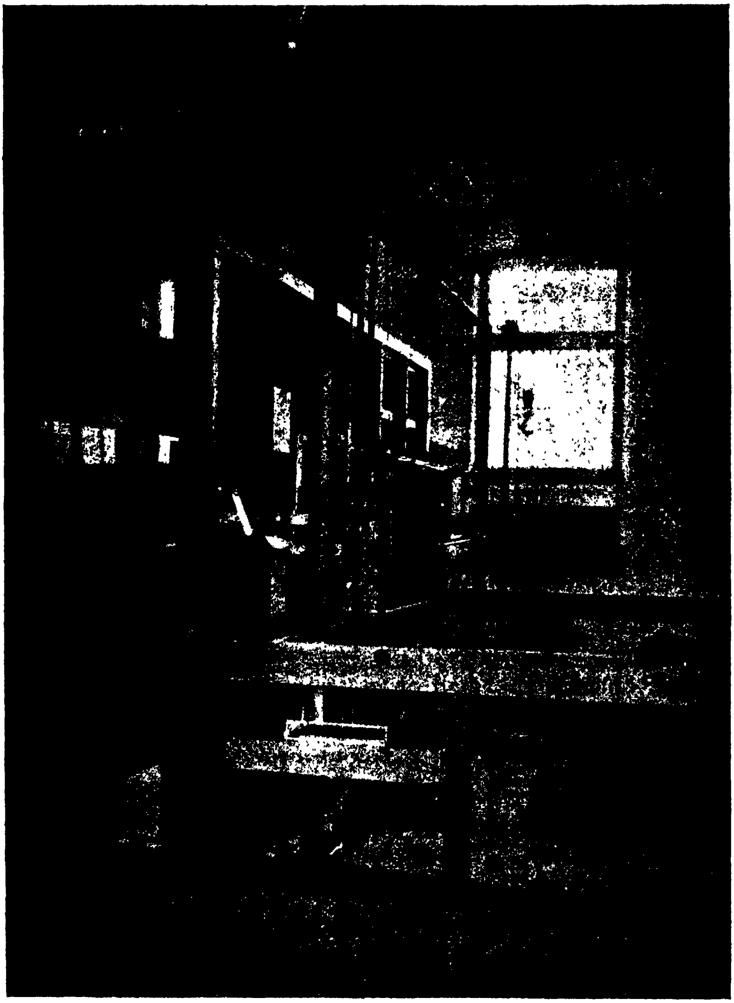

Fig. X.

X Ray Installation for Veterinary Purposes.

We must now devote our attention to modern applications of X-rays, and I shall confine myself to those strictly within my own experience. Since the use of X-rays for industrial, or rather war department purposes, was first seriously suggested by the Research Department, Woolwich, some seven or so years ago, we have devoted ourselves not only to the improvement of apparatus and technique, but also to propaganda. Various departments and individuals had to realise that this new method was bound to come. As I said in my second lecture, the fact that you were enabled to investigate the inner structure of materials without in any way damaging them is much too fundamentally important to be disregarded, even though the method is admittedly immature. We have had a very long fight, but I am really very delighted to be able to tell you that the work has now borne fruit. Not only are X-rays used very largely by the Government factories as a method of confirming the excellence of the metal castings they produced, and for other investigation purposes, but I have just been instructed to prepare designs of special X-ray apparatus for the purpose of routine inspection of war stores--fuses and so on. The moral factor of such inspection is not without significance. A workman will know that his finished work, sealed up though it may be, will be inspected by an infallible method exactly as he has left it. This fact will, undoubtedly cause him to exercise all the care of which he is capable, and, maybe, even a little more!

I have also to prepare designs of special installations for the use of the Air Ministry in the examination of aeroplanes. These routine uses are most gratifying, especially as they are the result of many years of weary demonstration, as the method has slowly improved.

I shall show you later a picture of a very efficient installation, designed and constructed in my laboratory, for veterinary purposes. It is installed in the Army Veterinary School at Aldershot, and is in very general use.

You will remember that I said in my last lecture that we were now able to penetrate three inches of steel. I am very glad to be able to tell you that only during the past week I have proved myself to be wrong. With certain apparatus, which has only just been completed, and upon which we have been engaged for some considerable time, we have been able to penetrate four inches of steel. This, I think, is the most that has so far been possible. The next slide (Fig. XI) is the radiograph we obtained.

I *have* heard it said that the Government is always somewhat dilatory and behind the times, but I think I have said enough to show that in the matter of radiological research, at any rate, it has set an example to industry which they would do well to take to heart. And what is true of radiological research is true also of all branches of science.

X-rays are very adaptable. You have just seen the maximum possible penetration.

The next slide shows, by way of contrast, how X-rays may be used to show such a delicate tracery as the circulatory system of a leaf. (A large number of slides were shown, illustrating the various industrial purposes for which X-rays might be used.)

I now want you to consider another modern application of X-rays. Perhaps it will prove to be the most valuable of all!

We have seen that we may examine the interior of a block of steel four inches in thickness, and also that we may see the inside of a baby mouse.

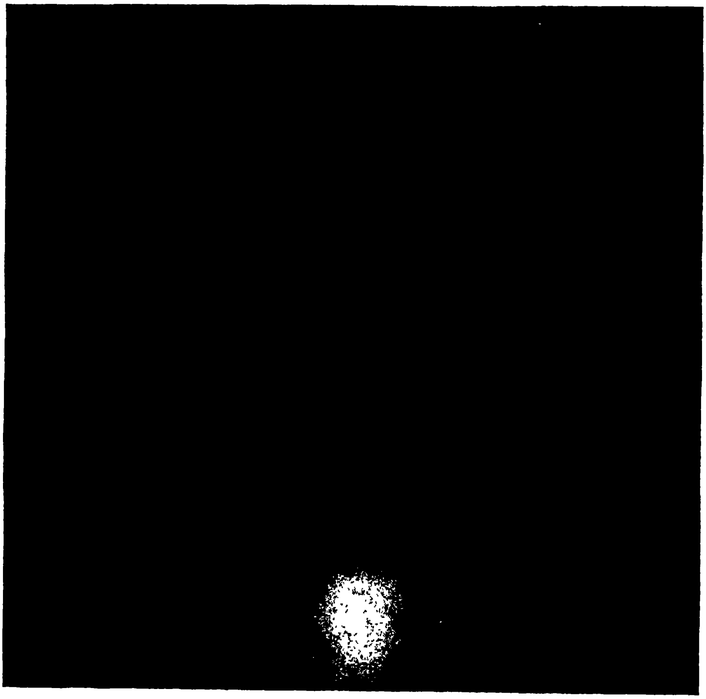

Fig. XI.

Radiograph showing penetration by X-Rays of 4 inches of Steel, obtained February, 1925, in the Radiological Laboratory, Research Department, Woolwich.

You will remember that if we have enough skill and experience we may investigate the inner structure of the *atom* by means of X-rays. Now the X-rays will also allow us to investigate the details of that hardly less fascinating structure *the crystal.*

I spoke of Professor Von Laue's wonderful inspiration when he used a crystal as an X-ray diffraction grating and so virtually settled the long X-ray controversy.

How does a crystal reflect X-rays?

In the first place, what *is* a crystal?

A crystal is essentially a symmetrical arrangement of a large number of structural units—made up of the atoms and molecules of the substance composing the crystal.

These units are arranged in perfectly symmetrical layers, and, of course, having three dimensions—consequently as the crystal grows these little units pile themselves up along three definite axes.

Crystals vary in character, through a very wide range depending on the directions of the axes. For example, if all three axes are at right angles, the crystal will belong to what is called the cubic system. Incidentally, most metallic crystals belong to this system.

The difference between a crystalline and an amorphous substance is simply that the crystal has *enough* of these symmetrically arranged units to enable the form to be recognised. Apparently amorphous material, on the other hand, *may* still be composed of crystals, but they are so very minute that they are not recognisable as such.

Now how does the crystal reflect X-rays?

These structural units in the crystal are separated from each other by distances of the nature of 10^{-8} cms.—approximately the wave length of an X-ray.

The word "reflecting" in this connection is a somewhat misleading term. X-ray reflection by a crystal is not at all like the reflection of light by a mirror, which is entirely a surface effect. X-ray reflection, on the other hand, is not a surface effect; the X-ray is reflected by the atoms *inside* the crystal, and this reflection is possible because the planes which intersect the space lattice of the crystal, as it is called, are separated by distances commensurate with the X-ray wave length.

Now just consider how varied in direction these atomic planes may be. Fig. XII is a diagram of a cubic crystal, showing the arrangement of these little structural units and the way in which these reflection planes may intersect.

The reflection of an X-ray beam, as you will see, is a very complicated thing, as each one of these units may take part. If, however, we consider

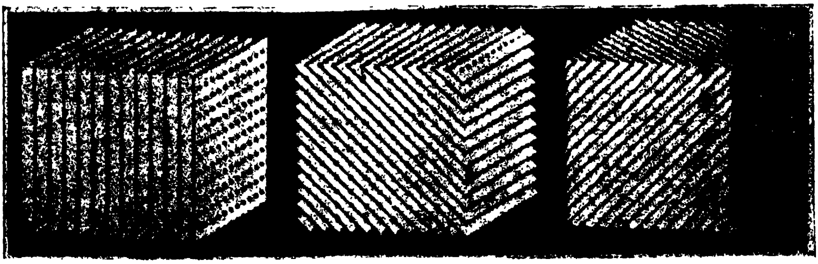

FIG. XII.

Diagram showing reflecting planes in a Crystal.

just one X-ray of definite wave length, it will be reflected by a crystal if *two* conditions are fulfilled. The angle of incidence must be just right and the distance separating the reflecting atoms must also be right.

There is a very simple relation between the X-ray wave length; the distance separating these planes, and the angle through which the X-ray beam is reflected.

The instrument used for the investigation of crystals by X-rays is due to Sir William Bragg. Like all manifestations of genius it is extremely simple. The difficulty about it is the interpretation of the results which it yields.

You will see that if we know the wave length of our X-ray and we observe the angle through which it is reflected, we may determine the distance apart of the little units composing the crystal in that particular plane, and if we turn the crystal round and repeat these observations all over we may reconstruct the form of the whole crystal. Conversely, if we know the structure of the crystal, we may analyse the X-ray beam and determine its wave length.

I have tried to give you a very general idea of this wonderful piece of apparatus, the X-ray spectrometer, and the way in which it operates. Its applications are far too numerous to mention. Sir William Bragg has done the most beautiful work with it on the analysis of very complicated organic crystals.

Westgren and others have investigated the crystal structure of iron and steel. In the Research Department we seek to apply the method to add to our knowledge of the properties of explosives, and of certain metals of service importance.

The question of strain in metals is one in which this particular method of investigation may have great value. It has been generally believed that strain in metals is accompanied by a slipping, as it were, of the unit planes in the crystal, one layer along another, but in a way which has not altered the crystal structure—the space lattice. Some work recently done by Czochralski, however, seems to suggest that this is not invariably true, that in certain cases of strain the arrangement of the little structural units in the crystal may actually be distorted. This, of course, is an ideal problem for the X-ray spectroscopic method of investigation.

We recently had occasion to investigate some specimens of charcoal which had been specially prepared to absorb gases. The specimens varied in their capacity for absorption, though no chemical difference between them could be observed.

X-ray spectroscopic methods showed that in every case there were two kinds of structure—the crystal structure characteristic of graphite, and another structure which had no crystal form at all. We were able, from a consideration of these results, to say that the best charcoal for the purpose was one in which the microscopic structure was modified by the process it had undergone and was characterised by the presence of a proportion of regularly arranged carbon atoms (graphite) and a proportion of irregularly arranged carbon atoms (the amorphous element).

Another application, which is a direct modification of Professor V. Laue's method, is due to my colleague, Mr. H. Pealing. The method has been very beautifully developed by Dr. Gilbert West. It is a quick method of determining the size of the crystals in a metal specimen.

A beam of X-rays is passed through a specimen of the metal, and each constituent wave length of the beam is reflected by its appropriate plane in crystals composing the metal.

The result is seen as a number of spots, rings or other markings on the developed negative. A proper interpretation of those markings yields information concerning the size of the crystals and other information of considerable interest regarding their orientation.

I have tried in these lectures to convey to you some idea of the development of X-ray research both theoretically and practically. I know that I have dealt most inadequately with the subject. My intention was to stimulate your interest and so to induce you to seek for more information. The results now obtainable, though they are far from perfect, are the product of many lifetimes of patient work. Scientific results do not drop from the blue at the feet of casual passers by; they develop slowly and are revealed by profound knowledge and unremitting hard work.

It is the imperative business of industry and the general public to support to their utmost bodies and institutions (of which a most illustrious example is the Royal Society of Arts), which are so strenuous and successful in making science known and also in encouraging scientific workers in their efforts, their failures and their successes.

It is a great pleasure to express my indebtedness and thanks to the Council of the Royal Society, the Director of the Science Museum, Sir William Bragg; Sir Herbert Jackson, and Mr. Campbell Swinton for their help and kindness in allowing me to reproduce certain illustrations; and particularly to my old friend and colleague, Mr. W. J. Wiltshire, for all his help, and for his skill and care in the preparation of many of the lantern slides.

OBITUARY.

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SAMUEL DIGBY, C.I.E.—Many Fellows of the Society, and especially those interested in the Indian and Dominions and Colonies Sections, will learn with deep regret of the death of Mr. Samuel Digby, which took place at a nursing home in London, on September 23rd.

Mr. Digby was born at Wisbech in 1853. He started his career as a journalist on the *Isle of Ely and Wisbech Advertiser*, which was also the training ground of his close and life-long friend, the late Sir Thomas Jewell Bennett, who, going out to Bombay, ultimately became the principal proprietor of the *Times of India*, and on returning to this country was elected M.P. for the Sevenoaks division of Kent, and was a member of the Council of the Royal Society of Arts at the time of his death in January last. Like Sir Thomas Bennett, Mr. Digby also went in early manhood to Bombay, where he was for some years assistant-editor of the *Times of India*. On his return to England, in the late eighties, he contributed London letters to the *Bombay Gazette* and the *Indian Daily News* (Calcutta), some of which work he continued to carry on up till last year.

In 1890 he was appointed Secretary of the Indian Section of the Royal Society of Arts, and in 1898 he also became Secretary of the Colonial (now the Dominions and Colonies) Section. About a year ago he was further entrusted with the editorship of the *Journal*. It would be impossible to speak too highly of the zeal and devotion with which Mr. Digby served his two Sections. He spared no pains to secure the very best speakers and chairmen, and he was tireless in his efforts to attract good audiences. Probably nothing gave him so much pleasure as to sit in his chair on the platform and contemplate a well-packed hall at one of his meetings. Thanks to his admirable work, both these Sections are now in a very flourishing condition, and as a result the Society is able to boast of a very large number of Fellows resident in India and in the various Dominions and Colonies.

Mr. Digby was Hon. Secretary for India of the Seventh International Congress of Hygiene and Demography held in London in 1891, and of the Eighth Congress held in Budapest in 1894. He also assisted in the movement which led to the appointment of a Select Committee of the House of Commons to consider the grievances of the Uncovenanted Services of India. He was created C.I.E. in 1907.

LOUIS STARR, M.D., LL.D.—Dr. Louis Starr, who had been a Fellow of the Society since 1917, died on September 12th, at Dinard, Brittany. Born in Philadelphia in 1849, he was educated at Haverford, Pennsylvania, whence he graduated M.D. in 1871. He held a number of important posts in connexion with various hospitals in Philadelphia, where he also built up a large private practice, and he was the author of several important medical works. One of the best known and most highly respected figures in Philadelphia, he was a warm friend of this country, and always eager to promote the union of the great English-speaking races. Writing of him in *The Times*, Sir Geoffrey Butler, M.P., says:—"Few familiar with Philadelphia of the last generation had not met that wisest of gentlemen and of family advisers, Dr. Starr; and there are many among those who lead in the life of the city to-day who, at the earliest possible moment of their existence, made the acquaintance of this large-hearted practitioner. But his many English friends have special reason for cherishing his memory. The death of his son, Dilwyn, as an officer in the Guards, who fell on the field of battle during the period of the official neutrality of the United States, snapped something in the life of his parents which nothing could restore. These, and other afflictions, made unbearable to him the surroundings of his earlier and happy years; and his wife and he moved to Europe to spend the time of his retirement. Afflicted by more than ordinary sorrows and anxieties he was upheld by a greater than ordinary serenity. He died in France, as his son died. Many in England will long be mindful of their debt to both."

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FRIDAY, OCTOBER 9, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

PROCEEDINGS OF THE SOCIETY.

NOTICE.

OPENING OF THE 172nd SESSION.

The Opening Meeting of the 172nd Session will be held on Wednesday, November 4th, when the Inaugural Address will be delivered by SIR THOMAS H. HOLLAND, K.C.S.I., D.Sc., F.R.S., K.C.I.E., Chairman of the Council. The chair will be taken at 8.30 p.m.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

THE INNER STRUCTURE OF ALLOYS.

By WALTER ROSENHAIN, D.Sc., F.R.S.,

Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory.

LECTURE I.—*Delivered Monday, February 16th,* 1925.

There are various aspects from which one may view the structure of metals. There is the grosser structure—what is called macrostructure—which can be seen in many cases by either examining fractures, or by deeply etching roughly polished surfaces, showing the general arrangement of the crystals of the metal. Then there is the more interesting, and in many ways more important, and certainly the more deepseated structure, which we know as the microstructure.

The inner structure with which these lectures deal, however, is something beyond that. It is really the atomic structure of metals—alloys—which is to be discussed. It is important because I think that in the knowledge which we have gained in recent years of the arrangement of atoms in crystals generally, and in the crystals of metals and alloys particularly, we shall find the key to that maze of facts concerning metals which has been accumulated by the labours of many research workers during the last 40 or 50 years, and by other workers, perhaps less systematic, during the centuries before them.

In order to explain how the new knowledge which we have gained about the atomic structure of crystals explains the facts of metallurgy, I should really begin by recalling some of the principal facts which it is proposed to explain ; but I do not propose to go through anything so extensive, but only to refer to a few of the principal facts which we have to explain. In the form in which I propose to put them before you they are already classified, summarised and condensed into something approaching a scientific knowledge of the subject, but when we have done all that can be done in that respect - by classifying and arranging our known facts—we are still faced by a maze of diversified data which, at first sight, appear to have no common system and no connecting link ; and it is that common system and that connecting link which the knowledge of the atomic structure will, I think, supply.

The constitution of alloys has been studied at great length, and with ever-increasing precision and detail during the last 40 years. The earlier studies can only be regarded now as pioneer attempts which gave maps of those alloy constitutions corresponding in their accuracy, or want of accuracy, with the kind of maps which were drawn round about the year 1500, when a map of the world was attempted ; they were crude, but useful. None the less, we have had to discard these crude maps and have had to devote an enormous amount of labour to the accurate study of alloy systems ; and that accurate study has not even yet been carried to anything like the length which is required to give us all the data to test the accuracy of the theoretical conceptions which we are now able to formulate.

When we know the constitution of alloys, we express it in the terms of what we call an equilibrium diagram. That sounds a little formidable, but is in reality quite a simple thing. We can say that we know all about the constitution of an alloy system when we are able to define exactly what constituents and in what proportions those constituents will be present in any alloy of a given chemical composition at any specified temperature—strictly speaking, between absolute zero and the boiling point of the metal, or even beyond it. As a rule, we do not concern ourselves very much with very low temperatures or with temperatures above the melting point, and the diagrams in which we represent our knowledge of the constitution of alloy systems usually indicate only the possible constitutions of those alloys between the ordinary temperature and the point at which they are completely liquid. If we take an alloy system of two metals—what we call a binary alloy system—the problem is comparatively simple, because we can represent the facts on a plane diagram. We plot that diagram by arranging that the distances between two points on a horizontal line shall represent the chemical composition, either in terms of the number of atoms per cent. or in terms of percentage by weight ; and we arrange, at right angles to that ordinates representing temperature. By drawing a sufficient number of lines on such a diagram, we can map out the whole of the constitution of an alloy system. When we speak of the constitution, it must be remembered that we can only define in a permanent satisfactory manner the equilibrium constitution—the constitution which the alloys will assume, given sufficient time and a sufficiently low rate of cooling —*i.e.*, the final stage which they tend to reach.

I will begin with one or two of these diagrams which have been most thoroughly studied. The first of them, shown in Fig. 1, is a simple one. It represents the alloys of zinc and cadmium.

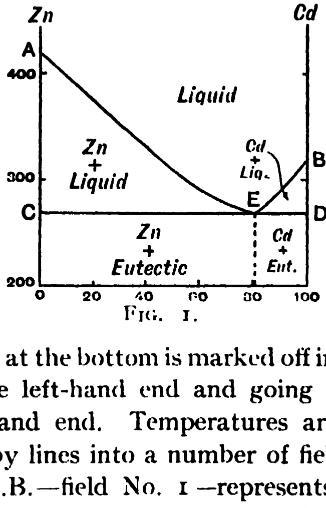

FIG. 1.

Here the horizontal line at the bottom is marked off in percentages of cadmium starting with zinc at the left-hand end and going up to 100 per cent. of cadmium at the right-hand end. Temperatures are represented vertically. The diagram is divided by lines into a number of fields. The first field at the top, above the line A.E.B.—field No. 1—represents the temperature range when the alloys are completely liquid. Along the line A.E. we have solidification commencing by the separation of zinc. Along the line E.B. it commences by the separation of cadmium. Next, there are two triangular areas in which the alloys consist of mixtures of solid and liquid. Then the horizontal line C.E.D. represents the end of the solidification process.

The next (Fig. 2) is rather more complicated. This represents the alloys of aluminium and magnesium according to a determination made at the National Physical Laboratory. Here we have a much more complicated set of conditions. Not only the two pure metals crystallise from their liquid solution, but there are also certainly two, and possibly three, intermetallic compounds making their appearance in that more complicated region in the middle of the diagram.

We pass on to another system (Fig. 3)—the system of copper-zinc alloys, in which we have a diagram of a still more complicated kind in which there are

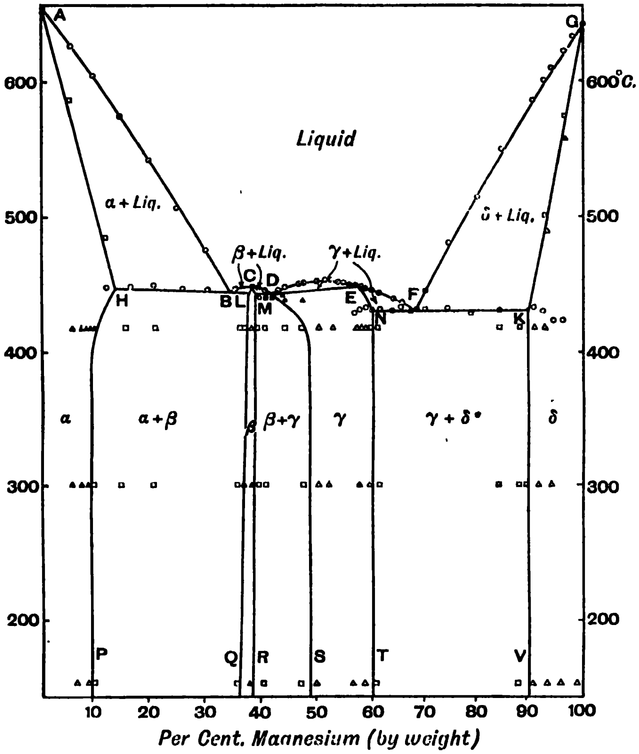

FIG. 2.

a large number of separate microscopic constituents represented by the various letters of the Greek alphabet. These are merely tokens, but it is convenient to speak of these various constituents by the names of Greek letters rather than by other names. This is a diagram of a very different type.

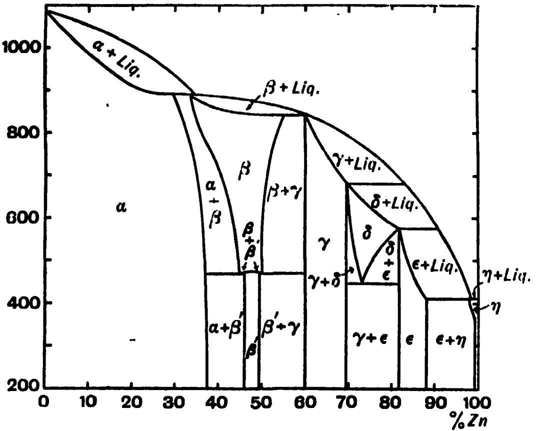

FIG. 3.

A still more complicated diagram is represented by Fig. 4—the alloys of iron and carbon. This is a complex system, in spite of the fact that it deals only with a short range. The diagram only extends to about 5 per cent. of carbon, for the simple reason that one never meets with alloys—in fact, it is very difficult to prepare alloys—containing much more than 5 per cent. of carbon. It is not necessary to go into detail as to the exact meaning of all these diagrams; the purpose of showing them is mainly to indicate the kind of information which we possess.

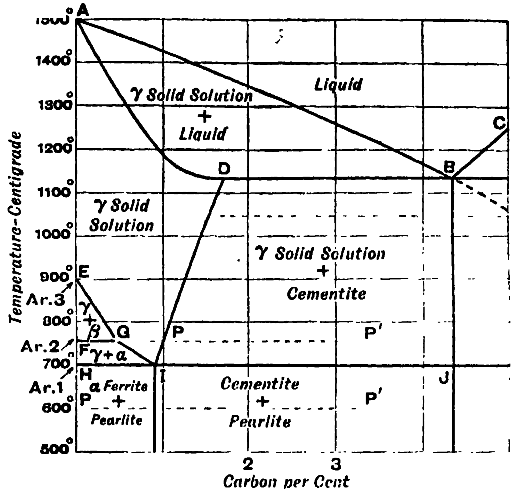

Fig. 4.

When we come to alloy systems of three metals—ternary alloys—matters are more difficult. One can no longer represent composition by points along a straight line. We have to represent composition by points on an equilateral triangle, and on such a triangle, as a base, we have to erect our temperature verticals. The result is that instead of the curves and lines representing the transformations which the alloys undergo, we now have surfaces, sometimes curved and sometimes plane, and the only way of representing those is by a solid model. Originally this was done by means of solid models made of plaster of Paris, but more recently the idea has come in of using models made of wire, which have the advantage that they indicate the various surfaces and yet allow all of them to be seen at once, which cannot be done in the case of a plaster of Paris model. Fig. 5 shows a photograph of one of these models.

It is a model representing the equilibrium conditions of a small range of the alloys of aluminium, copper and nickel.

Each of the surfaces indicated on this model represents the results of most careful determinations made by thermal measurements and microscopic examination, sometimes of little specimens of metal which have been maintained carefully at a constant temperature—constant to within 1°C—perhaps for

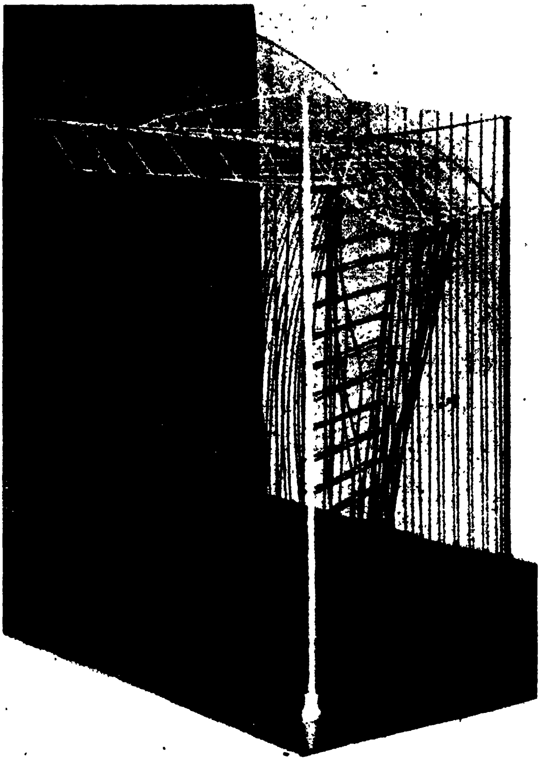

FIG. 5.

a month or more. Sometimes that has had to be followed either by very slow cooling or by very rapid cooling. By these methods, coupled with pyrometric observations, it has been possible, slowly and laboriously, to determine the nature of these equilibria and to establish these diagrams and models. There can be no question that in such a diagram there is a mass of most valuable information, but when a number of them are considered together it is very difficult to see exactly what they mean. Why is it that lead and tin give one diagram, copper and zinc another, aluminium and magnesium another, iron and carbon yet another, and so on, through a whole collection of different pairs or groups of alloys ? At first sight there seems to be no systematic connexion whatever between them, but I think it is possible to show that there is a connexion, and a very intimate and systematic one, which we can follow and understand.

But first a little more should be said about these diagrams because, after all, if we can explain their nature and meaning in terms of simple general principles, we shall have made a stride forward in our understanding of the facts of metallurgy.

Fig. 6 is a diagram—not of any particular alloy system, but a type. It is the type of alloys in which there is what is known as a continuous system of solid solution. The term " solid solution," of which I shall have a good deal more to say afterwards, is not so paradoxical as at first sight it appears. It means that two metals are melted together—metals of this kind of which copper and nickel are very good examples—when they solidify and are allowed to reach equilibrium by sufficiently slow cooling, they possess a microstructure which, in most respects, is identical with that of a pure metal. The solid metal is therefore built up of a mass of crystals which are chemically all alike. In other words, there is only one constituent in these alloys. It means that after complete solidification and equilibrium has been reached the state of intimate mixture which existed in the liquid solution of these metals has been preserved in the solid crystals. That is why we call them solid solutions. Now what happens in that case is this—that if the melting or freezing of these alloys is observed, and on a diagram of this kind the curves are plotted that pass through all the temperatures at which melting commences and at which freezing commences, two curves like X.Y.Z. and X.P.Z. are obtained—X.Y.Z. being the curve of commencing solidification and X.P.Z. that of complete solidification. It will be evident that at the points X and Z, representing the two pure metals, the two curves meet, but they diverge in the middle of the diagram to an increasing extent. That means that the alloys in the middle of that diagram, instead of melting or freezing at a single temperature, have a melting or freezing range ; and that is typical of all solid solutions, but there is no break ; there is a perfectly continuous line from one end of that diagram to the other.

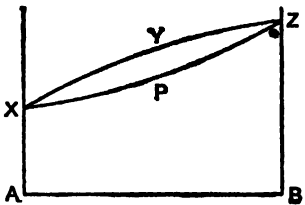

FIG 6.

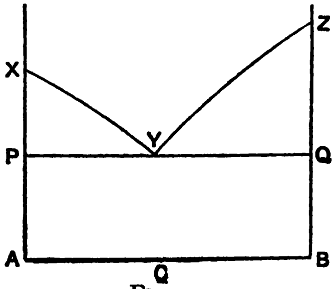

FIG. .7.

In contrast we have another type of diagram, shown in Fig. 7, in which the two metals are incapable of preserving a condition of mutual admixture when in the solid state. Strictly speaking, metals of that kind do not exist—that is to say, metals in which there is *complete* insolubility in the solid state, but there is a close approach to it in some cases. This diagram shows two branches in the curve representing the commencement of solidification, X.Y. and Z.Y. which meet at the point Y. Through that point we have a horizontal line P.Y.Q. which represents the end of solidification. Along the line X.Y., the metal represented at the end A crystallises out of the liquid, leaving a liquid residue which gradually concentrates in B, and finally, at the point P, when it reaches the line P.Y., the remainder solidifies in the form of what is known as a eutectic alloy. Similarly, along the curve Z.Y. we have separation of the metal B with a concentration of A in the remaining liquid. The liquid contains more and more A, as we remove B from it by successive crystallisation, until, finally, the same eutectic which forms along P.Y. forms also along Q.Y. We have along the side P.Y. crystals of the metal A embedded in this eutectic, and along the other side we have the crystals of metal B embedded in the same eutectic. At the point Y we have the pure eutectic, which is nothing more nor less than an intimate mixture of minute crystals, forming alternate laminæ of A and B. That is an ideal case which, strictly speaking, is never obtained in practice. An approach to it is found in some cases, but the majority of alloy systems are intermediate between the two types shown in Figs. 6 and 7. An intermediate diagram is shown in Fig. 8, which is typical of a great many alloy systems.

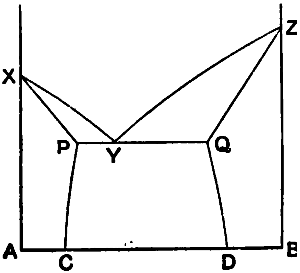

FIG. 8.

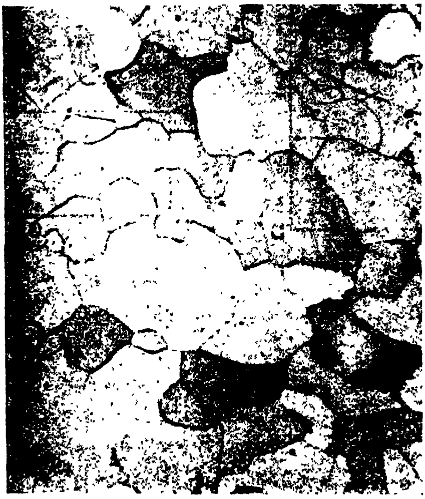

FIG. 9.

Here there are the curves X.Y. and Z.Y. meeting at the point Y. There is a separation of eutectic along P.Q., but between A. and C. and between D. and B. there is no separation of the two constituents. The metals are capable of existing in a state of admixture in the solid up to a certain concentration. There is what metallurgists call a certain limited solubility of one metal in the other in the solid state. They can crystallise together as homogeneous crystals until a certain definite concentration is reached. After that, a second phase, the eutectic occurs.

The microscopic appearance of some of these constituents, although not of vital importance in the present connexion, is still of some considerable interest. The first of the micrographs (Fig. 9) shows the structure of a pure metal.

In this case the metal is nearly pure iron. The whole field is divided into a number of roughly polygonal areas, each of which represents the section of a single crystal. It is an aggregate of crystals grown together into a solid lump, but each crystal has its own orientation which differs from the orientation of its neighbours. There is only one kind of crystal present.

Solid solutions, when they have attained equilibrium, have a structure exactly like that of a pure metal, but in the other kind of alloy system—the eutectiferous type—in which solid solubility is limited, entirely different kinds of structure are found. Fig. 10 shows an alloy of tin and lead containing only a few per cent. of lead. It consists of white crystals with a black and white dotted structure surrounding them. The white areas are the crystals of tin which were the first to solidify and the eutectic, which has completed the solidification, fills up the gaps between them. If the alloy contains rather more lead there is more of the eutectic. This is plainly seen in Fig. 11.

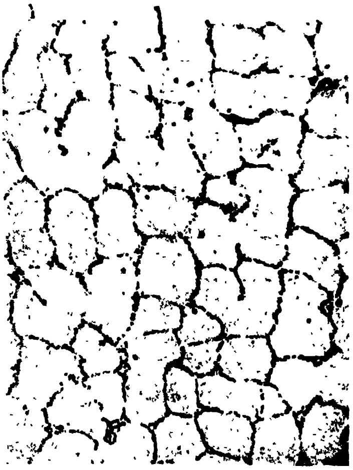

FIG. 10.

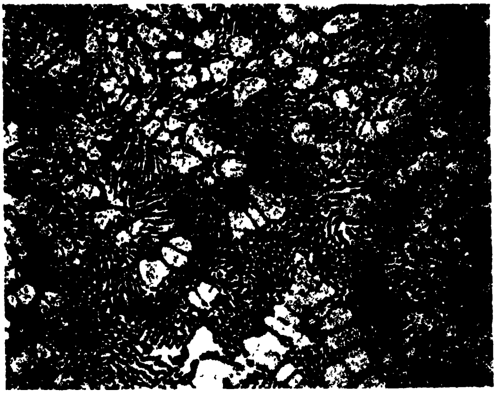

Fig. 11.

The white crystals of tin are much smaller and the amount of eutectic greater. Ultimately in alloys lying near the bottom of the V. in the equilibrium diagram of such a system, the whole area is occupied by eutectic, as seen in Fig. 12.

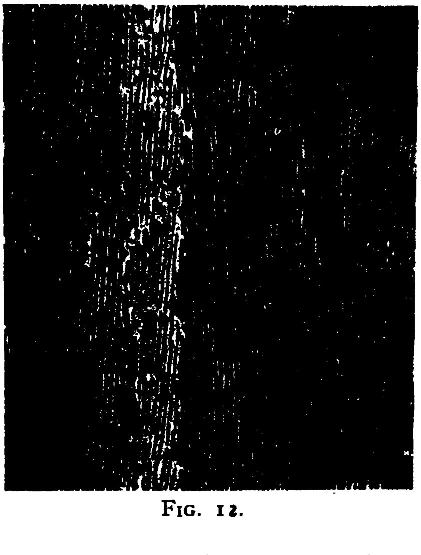

Fig. 12.

This eutectic constituent is really nothing more nor less than the two metals—in this case lead and tin—crystallised together in the most intimate fashion—not as one crystal, but as a mixture of two kinds of crystals.

Sometimes these finely laminated structures are formed by the breakdown of a solid solution. It sometimes happens that a solid solution remains stable down to a particular temperature, and then it breaks up into a mixture of two phases. The best known example is the well-known eutectoid—the pearlite of carbon steel, shown in Fig. 13. For many years it was thought

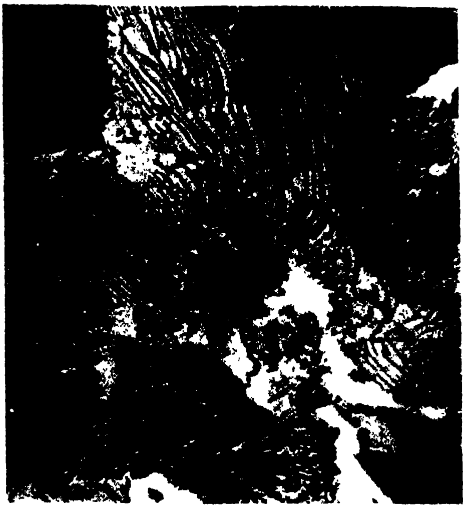

Fig. 13.

that this was unique—that there were no other substances forming eutectoids of this kind, but more recently my colleague, Mr. Archbutt, and I discovered in the aluminium-zinc alloys a eutectoid which very closely resembles in structure, and in many other ways, the eutectoid of steel. This is shown in Fig. 14.

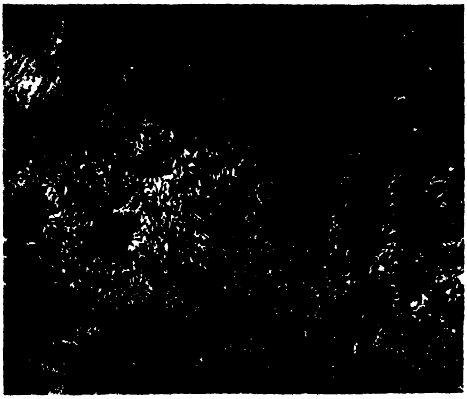

Fig. 14.

It is very like the iron-carbon eutectoid.

In the more complex alloy systems there are some other types of constituents. These are the second and third phases, generally called β and γ. Fig. 15 shows the α and β phases in a copper-aluminium alloy containing 7 or 8 per cent. of aluminium. These two constituents do not show the eutectic structure. They are both solid crystals, but they are two totally different bodies.

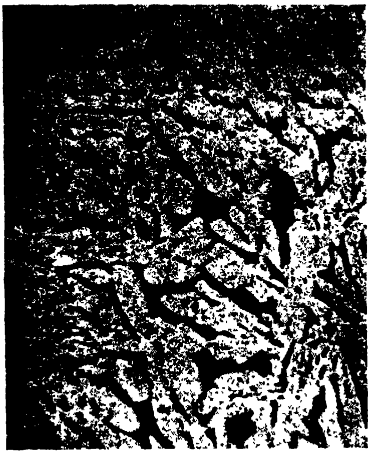

FIG. 15.

These bodies which we see under the microscope as the constituents of metals are crystals. It has remained for a very recent advance of physical science to give the final demonstration of that fact; but long before the modern methods of X-ray analysis were thought of metallurgists were able to prove clearly and satisfactorily that those bodies were crystals. That proof was first given by the late Dr. J. E. Stead, and others added to that proof from time to time. I would recapitulate that proof, because it is interesting in the light of more recent and more complete knowledge.

Fig. 16 shows a section of a piece of very pure clean iron, deeply etched, and viewed under the ordinary normal illumination, the light falling vertically downwards upon the surface; the various polygonal grains are outlined by thin lines, and are differentiated from one another by variations of tint. If, instead of being illuminated by light falling vertically upon it, such a surface is illuminated by light falling obliquely upon it, a different effect is produced—

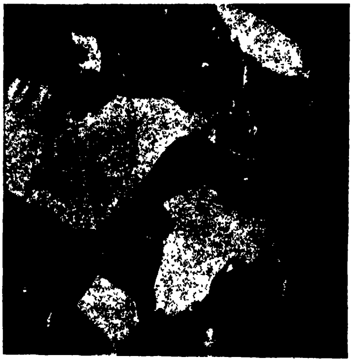

FIG. 16.

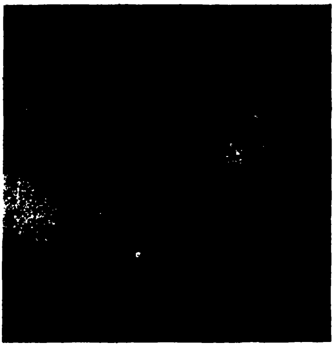

FIG. 17.

an effect which bears to the first picture almost exactly the relation of a negative to a positive. These two aspects of the same structure are seen in Figs. 16 and 17.

The reason is that the etching re-agent which has been used in preparing these specimens attacks the surfaces of the crystals and, to a certain extent, unbuilds them and reveals their structure by developing upon the surface a series of minute facets. Those facets are all similarly directed in one crystal, but the direction varies from crystal to crystal. When light falls vertically upon such a facetted surface, those facets which are most nearly horizontal reflect the greater part of the light back into the microscope. Those which are inclined reflect some of it away and therefore appear less bright. When the light falls obliquely upon the surface, that state of affairs is reversed, and those areas which were dark before, now appear bright, and *vice versa;* if either the light or the specimen is rotated, these crystals flash up in turn just as if they were little mirrors arranged at various angles. That is what they actually are, but instead of being single mirrors they are thousands of tiny mirrors. It is sometimes possible to see these tiny mirrors under favourable conditions. One of the most beautiful examples is obtainable by deeply etching the surface of a piece of silicon steel. That was done by the late Dr. Stead, who very kindly presented some of his micrographs to me. One of them is reproduced in Fig. 18.

Sometimes these facets can also be seen on other metals.

FIG. 18.

FIG. 19.

Fig. 19 shows a surface of tinplate on which the facets have been developed. We have here the junction of two crystals, and it will be seen that the facets are differently arranged in the two.

Fig. 20 shows the crystal structure revealed in yet another way. This is from a piece of cadmium which has been allowed to solidify in contact with

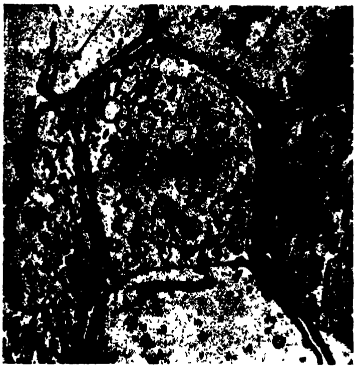

Fig. 20.

glass. There was a little layer of gas or moisture on the glass, which could not escape, and the crystal had to build itself round those little particles of gas or moisture, and in so doing it left these beautifully geometrical pits or holes to accommodate the little bubbles of moisture, thus revealing in a beautiful way the uniform orientation and architecture within each grain and the change of orientation from one grain to the next.

That is the structure of a simple metal, but there are other constituents besides simple metals in our alloys. Solid solutions and eutectics have already been mentioned. We have now to consider those puzzling things intermetallic compounds. At first sight chemists would have thought that two metals, being both chemically closely alike, would not form definite compounds. Nevertheless, they do, and we have to reckon with the fact, because those compounds are very characteristic and very troublesome bodies. They are generally peculiar in that they tend to form angular crystals, and are nearly always hard and brittle.

Fig. 21 shows an example of the appearance of one of these compounds in a

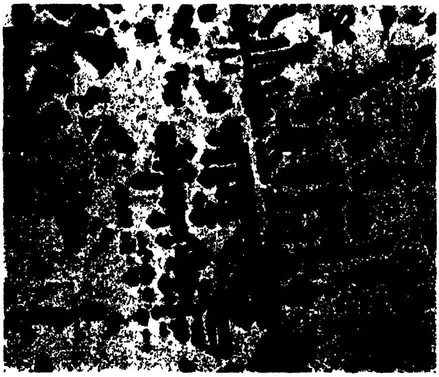

Fig. 21.

microsection. This is the compound Mg_2 Si. which has crystallised from solution in an aluminium-silicon-magnesium alloy, and the forms which it assumes are obviously crystalline and geometrical.

There are many other compounds between metals—for instance there are copper-tin and antimony-tin compounds which exist in white bearing metals. Fig. 22 shows these as white stars and cuboids on a dark background. This is an alloy consisting mainly of tin with antimony and copper; the little star-shaped crystals are the copper compound and the little cuboids are the antimony. Those little hard crystals have a great deal to do with the usefulness of the alloy as a bearing metal, but our interest in them for the moment is rather as types of the characteristic qualities of intermetallic compounds, differing in that respect essentially from solid solutions, which are, as a rule, tough and ductile, while intermetallic compounds are hard and brittle. An interesting and characteristic example is the compound of aluminium and copper—Cu Al_2. It contains rather less than 50 per cent. of aluminium and takes the form of beautiful silver-white needles which can be obtained by melting equal quantities of copper and aluminium together, pouring the molten metal into a suitable mould, and when crystallisation has gone a certain distance, emptying out the liquid. This leaves behind these beautifully needle-shaped crystals. They are exceedingly brittle. That is a remarkable fact, considering that aluminium and copper are two of the most ductile of the common metals. Yet here is an intermetallic compound of the two which is very brittle and altogether different from either copper or aluminium—that being characteristic of a chemical combination. What is the explanation of all these things?

FIG. 22.

The explanation of this and many other facts would have been difficult were it not that physicists have developed a method of studying the atomic structure of matter by means of X-rays, which has given results of the most extraordinary interest and far-reaching importance. That method was developed first of all from a discovery made by Laue—that a crystal can diffract X-rays. What we mean by that is simply this: If a train of light waves falls upon a series of obstacles placed regularly at distances apart, which are of the same order as the length of the light waves themselves, the well-known phenomena utilised in the diffraction spectroscope for producing a diffraction spectrum, appear. Each of these obstacles acts as the source of a new light wave. The light is scattered by each of these obstacles, and if it so happens that the light from the successive obstacles reaches a screen, or the eye, in such a manner that the waves sent out from one obstacle reinforce and coincide with the waves sent out from the next, and so on, then there is a very bright reflection at that particular point, but there are other points where the crest of the wave sent out by one obstacle coincides with the trough of the wave sent out by the next, and those waves extinguish one another. At such a point there is no reflected light at all; there is darkness. The arrangement of light and darkness in the reflected beam depends upon the spacing of the obstacles and upon the length of the waves of light which is used. If one is known, by measuring the spacing of the shadows and lights on the screen, the other can be determined. In other words, if light of a known wave length falls upon a grating—a series of lines ruled on the reflector—and the distances apart of the light and dark bands in the reflection from that reflector are measured, the distance apart of the lines in the grating can at once be calculated, or *vice versa*, if the distance apart of the lines of the grating is known the wave length of the light that is falling upon it can be calculated. The wave length of the X-rays is from 1,000 to 50,000 times smaller than the wave length of the shortest wave of visible light, and consequently we cannot rule upon any ordinary surface—in fact, we cannot produce artificially—any series of obstacles close enough together to give this kind of effect. We can rule, perhaps, 200,000 lines to the inch, but we cannot rule 20 millions or 200 millions to the inch. If we could, our materials would not be fine enough to stand them. But, fortunately, Nature has done it for us by arranging, in the crystals, atoms and molecules grouped at distances apart which are just about right to produce this effect with the minute wave length of X-rays. There was for long a controversy as to what X-rays were—whether they were pulses or corpuscles, but ultimately the idea predominated that they must be waves, and the idea of waves once having been accepted the next step was to find some means of analysing those waves, and Laue hit upon the idea that the spacing of the atoms and molecules in a crystal, where presumably they would be regularly arranged, would be just the thing. He showed mathematically what ought to happen, and then did it, and a new path was opened for the investigation of the inner structure of matter. I am not now referring to the structure of the atom itself, about which we have heard so much of interest and importance, but of the manner in which atoms are arranged in crystals and molecules. What happens with the X-rays passing through a crystal, or reflected from it, is exactly the same thing as occurs when light is diffracted from ruled lines on a mirror. The various layers of atoms act as successive reflectors, and according as those layers of atoms are certain distances apart—according as that distance is such as to make the reflections reinforce each other crest to crest or blot each other out crest to trough—so we get light or darkness—X-ray light or darkness—upon the screen, and we can determine the existence of a reflection or darkness by various means—by a photographic film or by what is called an ionisation chamber, which measures certain electrical effects which the X-rays produce when they pass into a chamber containing certain gases. That method has been very much developed from the days when Laue began it. Laue's method has certain limitations, but it has been developed by Sir William Bragg and A. L. Bragg in this country, by Hull in America and by Scherrer and Debye on the Continent, into a very powerful weapon for crystal analysis. As a result of that crystal analysis we now know not only the wave length of the X-rays, but the exact distances apart of the atoms in a great many crystalline substances. When I say "exact," I think it is right to say that in many cases those distances are known, minute as they are, to an accuracy of less than one half of one per cent. One must remember that those distances are of the nature of 2 to 5 Ångström units, and an Ångström unit is one ten-millionth of a millimetre. It is possible by this means to measure a distance of 3 Ångström units to one-three-hundredth of an Ångström unit, and a measurement of that degree of precision is almost unthinkable. None the less, it is perfectly attainable and the time is not far distant when, if only the atoms are regular enough, we shall be able to measure those distances to perhaps ten times that degree of accuracy; but we are now meeting the difficulty that the crystals themselves are not sufficiently perfect and regular.

As a result of this development, carried out by physicists entirely for its own sake, without thought of benefit to the metallurgist, facts of very great importance have been brought out about metals. Those facts are a long story, and I can only deal to-night with the facts about pure metals. What has been discovered is this—First of all that metals are crystalline. That was not a new discovery; the metallurgist had discovered it 20 years ago; but the X-ray analysis tells us more than that. It tells us, not only that we have crystals and what kind of crystals, but the exact way in which the atoms of the metal are arranged in those crystals; and that method of arrangement is of a very interesting and peculiar character. The atoms are arranged on what we might call networks, usually termed "space lattices." The term "space lattice" has a formidable sound, but it is really quite simple. If a number of parallel lines equi-distant one from another on a plane are imagined spread out through a large volume of space, and intersecting them at right angles, another system of lines on the same plane; then we have a plane extending through a large region of space divided into squares. Multiply that plane indefinitely one above the other, at distances from each other equal to the side of the square which is ruled on each plane. We then have a set of planes each divided into squares one above the other, and by joining them up we produce, without altering anything but merely drawing additional lines, vertical planes in both directions, also divided up into similar squares. In the region of space thus divided up into cubes, we have a space lattice—the simplest of all space lattices—a simple cubic lattice. It is obvious that space can be divided up into bodies of different shapes in a variety of ways by systems of lines of that kind. Of the numerous possible lattices of this sort, upon which atoms might be arranged, it fortunately happens that in metals we encounter only a few.

Fig. 23 shows a rough diagram of what is really the commonest of all space lattices in pure metals. This is what is known to crystallographers and to X-ray physicists, as the face-centred cubic lattice. A single unit of lattice is shown on the right-hand side and a diagram of 3 x 4 x 3 of these units arranged together is shown in the larger figure. Each face of the cube has the diagonals drawn across it in order to show the position of the atom at the face-centre. In a metal in which the atoms are arranged upon the face-centred cubic lattice, there would be one atom centred on every one of the corners of the cube and on the face-centres. In a unit cell of the lattice there would then be 8 at cube corners and 6 more at the centres of the faces. There would be in that unit cube 14 atoms in all. It must be remembered, however, that when the unit cells are built up together, each atom at the corner of the cube is divided up among 8 different cubes. It belongs as much to each of those 8 as to any one of them, so that one must say that the unit cell of the lattice contains only one-eighth of these 8 cube-corner atoms, and it contains only half of each of those at the face-centre, because each one of the face centres belongs to both of two cubes, so that we have one-eighth of 8, that is, one atom, belonging to the unit cell, plus one-half of 6, that is 3. In other words, there are four atoms to the unit cube in that lattice.

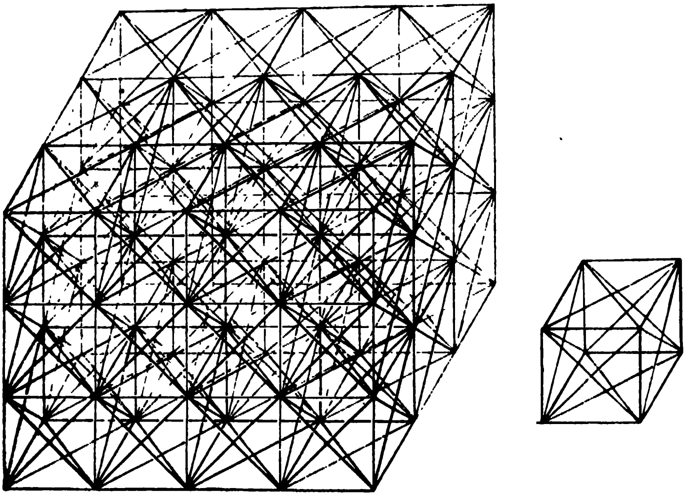

FIG. 23.

Another space lattice which is sometimes found, although not nearly so frequently, in metals, is the body-centred cubic lattice. It consists of unit cells which are cubes, but there are no atoms located on the centres of the faces but only in the centre of the body of the cube. A diagram of the unit cell is shown in Fig. 24.

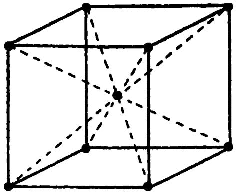

FIG. 24.

Of the eight atoms at the corners of the cubes each belongs to eight cubes. They, therefore, represent only one atom per unit cell, but the atom in the middle of the cube belongs to that cube and to no other. So that here there are two atoms for the unit cell whereas in the other làttice there were three. That is typical of another fact. If spherical balls of any kind are piled up, if they are piled together as closely as possible, centres of the spheres will lie on the face-centred lattice, although an alternative arrangement—the hexagonal—is possible. They can also be piled so as to make the body-centred arrangement, but they then occupy a larger space ; they are less closely packed. We, therefore, speak of the face-centred lattice as being " close packed." The body-centred lattice is not close-packed. But there is another way of close packing. In order to obtain the face-centred lattice the successive layers of spheres must be arranged in one particular way, but there is another way in which they can be packed— not identical with the face-centred method, but leading to the same result so far as density of packing is concerned. That leads to hexagonal packing.

The symmetry of the corresponding lattice is less perfect, however, than the symmetry of the cubic lattice. The cubic lattice is alike from whatever direction it is looked at. The hexagonal is only alike from two directions, so that it has a lower degree of symmetry, and that brings with it certain characteristic differences of property. Since metals like zinc and cadmium follow this hexagonal method of crystallisation, whereas copper, aluminium; gold and silver, follow the cubic system, it is evident that the hexagonal form represents a different type of property. But all metals are not so regular in their crystallisation as those just mentioned. There are others, for instance, bismuth, antimony and arsenic, which crystalise in a somewhat different way. There space is no longer divided into a perfectly symmetrical system of cells, either cubic or hexagonal, but the cube is slightly distorted into a rhomboid. Not only this, but there are two interlacing sets of lattices. The result is a structure which is actually very close to the face-centred lattice, but distorted through a small angle. Antimony and bismuth are brittle—not ductile—and they differ in many respects from the metals following the cubic and hexagonal lattices.

In concluding this lecture, it will be desirable to consider the actual numerical data for the interatomic distances—what we call the lattice constant, which is the size of the unit cube of the lattice. These have all been determined now, some of them perhaps not on samples of as high a degree of purity as desirable, but the values are none the less reliable.

Table I. (See Appendix) gives a list of most of the metals, with their interatomic distances. That is the distance, centre to centre, of the points about which the atoms swing. It must be remembered that these atoms are not at rest at ordinary temperatures, but are in considerable agitation, swinging about through certain distances, but centred about the points, whose distances apart in Ångström units are given here. They vary between just under 3 (2.96) in the case of cadmium to something about 6½ Ångström units. These figures, in some cases, are given to three places of decimals, and there is ground for thinking that these dimensions are known to that kind of accuracy. These inter-atomic distances or lattice constants differ quite appreciably one from another, and one may ask, Why? The answer, which might frequently be given, is that the atoms of the different metals are different in size, but it is necessary to be cautious about such a term as the "size" of an atom. So far as we know, the atom is a kind of solar system. It is a centre—nucleus—surrounded by groups of electrons in rapid rotation, and it may be that a system of that kind effectively *occupies* a certain volume. It certainly does not *fill* it, and it is a mistake to think of atoms as if they were solid spheres which can be packed tightly together and which would only pack in accordance with a certain definite dimension. As an illustration, I may mention that by the use of very intense pressures of several hundred tons per square inch, Bridgeman has succeeded in compressing metals to something like two-thirds the volume which they would occupy if the atoms were at rest, and if they really had the "sizes" which are normally attributed to them. If it is possible to squeeze the atoms up in that way, we can no longer regard them as rigid spheres; normally, however, they keep at certain distances apart from one another and they do so because at those distances a balance is set up among the forces between them. That balance of forces depends upon this—that there are certain attractive and certain repulsive forces at work. The attractive forces have a longer range than the repulsive forces. In other words, they diminish at a lower rate than the repulsive forces on moving away from the centre of the atom. It has been suggested that the attractive force diminishes as the cube of the distance and the repulsive force as the ninth power. That gives results which are not very different from the facts that we know, but we must regard the atom as an object which exerts forces upon its neighbouring atoms.

In some cases the forces are such that other atoms locate themselves most comfortably at a certain distance away, but mechanical means, and other means—such as chemical combination—induce those atoms to come very much closer together, or pull them further apart, within certain definite limits only. If they are pulled too far apart they part company; the attempt to press them too close together meets with such enormous opposition that the materials at our command do not suffice to go any further. We cannot think of atoms as rigid spheres. Perhaps it is a fairer analogy to think of them as tiny inflated balloons, but even that is a very dangerous analogy. The best way is to think of the atom as a system exerting forces, and the forces which

APPENDIX.

TABLE I.
CRYSTAL STRUCTURE OF METALS.

Substance.	Crystal Structure. Type of Lattice.	Crystal Structure. Axial Radio.	Lattice Constant Side of Elementary Cube or Hexagon.
Sodium	Body-centred cubic		4.30
Magnesium	Hexagonal	1.624	3.22
Aluminium	Face-centred cubic		4.05
Silicon	Tetrahedral cubic		5.43
Titanium	Hexagonal close-packed	1.59	2.97
Vanadium	Body-centred cubic		3.04
Chromium	Body-centred cubic		2.895
Iron	Body-centred cubic (α)		2.86
	Face-centred cubic (γ)		3.60
Cobalt	Face-centred cubic		3.554
	Hexagonal close-packed	1.633	2.514
Nickel	Face-centred cubic		3.540
Copper	Face-centred cubic		3.60
Zinc	Hexagonal close-packed	1.860	2.670
Molybdenum	Body-centred cubic		3.143
Palladium	Face-centred cubic		3.950
Silver	Face-centred cubic		4.060
Cadmium	Hexagonal close-packed	1.89	2.960
Tin (grey)	Tetrahedral cubic		6.46
Antimony	Rhombohedral hexagonal	2.647	4.28
Tungsten	Body-centred cubic		3.150
Platinum	Face-centred cubic		3.930
Gold	Face-centred cubic		4.08
Mercury	Tetrahedral hexagonal	1.88	3.84
Lead	Face-centred cubic		4.92
Bismuth	Rhombohedral hexagonal		4.54

the atoms exert depend upon where they are situated in the periodic table of the elements, or upon their atomic numbers.

Here we must leave the matter to-night; the next lecture will deal with the question of the interaction of different kinds of atoms when they are brought together in a single crystal.

NOTES ON BOOKS.

A TREATISE ON LIGHT. By R. A. Houstoun. Fourth Edition. London: Longmans, Green and Co. 12*s*. 6*d*. net.

INTERMEDIATE LIGHT. By R. A. Houstoun. London: Longmans, Green and Co. 6*s*.

Dr. Houston's larger volume, the Treatise on Light, has grown steadily in public estimation since the appearance of the first edition in 1915, and it is now looked upon as quite the standard volume for the man who wants a treatise not too heavy for the hand, yet, at the same time, full and concise, because unwasteful in the use of words.

So generally appreciated is Professor Houstoun's Treatise on Light that it needs no praise in a review, but we may touch on a few features of interest. The frontispiece, which shows chromatic spectra, includes that of the mercury arc, which contains no red, and that of cobalt-blue glass, which contains much red. We also see the almost or quite discontinuous swan spectrum as given by the low blue edge of a candle flame, and on the same plate as the spectra there are the two three-colour systems as used in chromatic photography; green-red-blue for taking and for additive reconstitution, and yellow-red-blue for subtractive reconstitution as in printing. In the text is a notably complete summary as to the various methods for photography in colours (pp. 346-348).

Planck's quantum is lucidly studied in its latest aspects (p. 472), and the account of "The Einstein Star Shift" and its bearing on the doctrines of relativity (pp. 469-471) is elucidated by three diagrams in the text (Figs. 331, 332 and 333). It thus becomes apparent that this fourth edition of Houston's Treatise on Light is well up to date and fully illustrated in the text.

"Intermediate Light," the smaller volume by Dr. Houstoun, may be regarded as an introduction to or epitome of the Treatise; the higher mathematics being omitted and the text reduced to about one-third. It seems admirable as a school book or a general reading book, also as an aid in preparing for the primary or early examinations of our Universities.

CORRESPONDENCE.

ALCOHOL FOR MOTORS IN THE TROPICS.

The news of experimental or small scale production of alcohol in North Borneo contained on page 973 of the *Journal* of September 18th, prompts me to point out that with present methods large volumes of water are consumed in the production of this fuel. In many parts of the world the tropics produce suitable growths for the extraction of alcohol, but not the necessary large volume of water. Some twenty years ago I had a visit from officials of the Society of Motor Manufacturers and Traders to view a car here running on alcohol.

A. E. PARNACOTT,
M.I.Auto.E.

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FRIDAY, OCTOBER 16, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

PROCEEDINGS OF THE SOCIETY.

◆

NOTICE.

OPENING OF THE 172nd SESSION.

The Opening Meeting of the 172nd Session will be held on Wednesday, November 4th, when the Inaugural Address will be delivered by Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., Chairman of the Council. The subject will be "The Organisation of Scientific Research throughout the Empire." The chair will be taken at 8.30 p.m.

PROCEEDINGS OF THE SOCIETY.

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CANTOR LECTURES.

THE INNER STRUCTURE OF ALLOYS.

By Walter Rosenhain, D.Sc., F.R.S.,

Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory.

Lecture II.—*Delivered February 23rd,* 1925.

In the first lecture the atomic or lattice structure which has been discovered and established in the case of pure metals was briefly explained. We have now to consider what is the real subject of these lectures—namely, the atomic structure of alloys. Let us begin by recalling to our minds the various constituents with which we have to deal in alloys. Of course, pure metals are sometimes found, but as a rule the constituents are either solid solutions or intermetallic compounds. Even in so-called pure metals we rarely find anything so pure that we can ignore the presence of dissolved impurities. The constituents with which I want to deal first are those which are really the predominant and most important constituents in metals, generally called solid solutions. That term, paradoxical as it may seem, is justified by the fact that in such a constituent we have a crystalline substance, homogeneous in composition, not only throughout each crystal, but from one crystal to another; so that after solidification—after equilibrium has been attained—a condition of intimate mixture is maintained in the solid state which resembles as closely as possible the condition of intimate mixture which exists in the liquid solution. Therefore the term " solid solution " by analogy is justified.

Let us recall how these solid solutions are formed.

Fig. 8 (Lecture I.) is a typical equilibrium diagram of a binary alloy system in which there is partial solid solubility of the two metals in one another. There is a region at either end—the region XPCA on this side, and XQDB on the other—in which the metal is wholly solid, and consists of homogeneous crystals all alike in chemical composition; but that region is limited to a certain concentration which may vary with the temperature; and beyond that the alloys consist of a mixture of the two solid solutions in the form of eutectic. That is the typical diagram. Sometimes the gap between the two regions of solid solubility is very small, and sometimes it disappears entirely, and then we have complete solid miscibility. It should be noticed that the two metals, as a rule, have different melting points, and that only the pure metals have single definite melting and freezing points. The intermediate alloys have a range of solidification or of melting, and therefore have not a single, definite melting point, but a region in which they are partially solid and partially liquid, in equilibrium. That is most important, because it is one of the striking features about solid solution alloys, which the ideas to be put forward serve to explain pretty clearly.

The micro-structure of a solid solution when equilibrium has been attained is exactly the same as that of a pure metal. It consists of homogeneous crystals. A homogeneous crystal, consisting of atoms of two kinds, might be constructed in several different ways. The Germans have long called these solid solutions " mixed crystals." That, in a sense, is not actually the German term. Perhaps a better translation of it would be " mixture crystals," but it has been translated by the term " mixed crystals." It is, however, somewhat misleading, because it suggests that each crystal is a mixture of minute crystals of the two metals. That was a theory which was held for a long time, but the evidence entirely disproves its possibility. There is no mixture of minute crystals of two different kinds in these solid solutions. The crystals are strictly homogeneous, at any rate to a much finer extent than distinct groups of atoms of the two kinds would indicate.

If one thinks of the atoms arranged on a space-lattice, there are two ways in which the two kinds of atoms can be mixed. There is obviously one way in which the lattice could be occupied indiscriminately by either kind of atom. The crystal would then be built more or less haphazard of the two kinds of atoms, just as a bricklayer having red and white bricks could mix them up anyhow in building a wall. The other alternative is this—that the lattice remains a lattice of the solvent metal, but that the other atoms are somehow or other pushed into what we might think of as the interstices between the others. At first sight it would seem difficult to discriminate between the two, but, fortunately, X-ray methods have made it possible to decide definitely between them—and in this way. If the atoms of the solute replace the atoms of the solvent atom for atom on the lattice, then the resulting crystal will have a definitely calculable density. We know the weight of each atom to a very high degree of accuracy, and we can measure by X-rays also to a high degree of accuracy the average spacing of the atoms, and if we find on comparing the density calculated from those two figures with the actual density of the alloys determined by direct measurement that those densities agree, we have conclusive evidence that that is the arrangement; because if the dissolved atoms were present interstitially, then we would have a higher density than in the case where they replace the solute atoms. That measurement was made for the first time by two of my colleagues, Dr. Owen and Mr. Preston, at the National Physical Laboratory on the alloys of copper and aluminium, and similar measurements have since been made on a number of solid solution alloys, and the result is quite unmistakable. The conclusion is justified that in all truly intermetallic alloys there is nothing but substitution. The density and the X-ray measurements combined serve to show clearly that the atoms of the dissolved metal must be placed on the lattice of the solvent metal, and not interstitially. At the present time there is one, and only one, known exception, and that is the solid solution of carbon in iron above the transition temperature, *i.e.*, in the γ region. In that case there is evidence to show, from a comparison of the densities and the X-ray data, that the carbon atom occurs interstitially in the iron lattice. Exactly how it is placed we do not know. It may be a case of definite chemical combination, each carbon atom being attached in some special way to three of the iron atoms, and therefore placed interstitially between those atoms. That seems to be a very exceptional case, and so far no other case among all the alloys yet studied—and a good many systems have been studied—has been found. Broadly speaking, therefore, it may be said that the substitution hypothesis is definitely established.

As an example, we may take the data for one system—the alloys of copper and aluminium at the copper end of the system containing up to 7 or 8 per cent. by weight of copper.

In Fig. 25 the change of lattice constant is shown; that is to say, the change in the dimensions of the primary cube of the face centred lattice in those alloys with increasing concentration of aluminium. The lattice is expanded. The average dimensions of the lattice increase with increasing percentage of aluminium. With concentrations up to 8 per cent., the lattice parameter increases from about 3.615 Ångström units to about 4.7. If the densities are

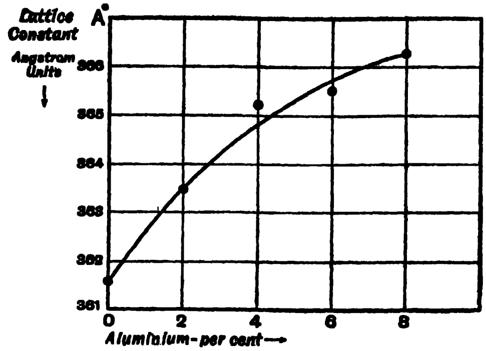

FIG. 25.

calculated from those figures on the two hypotheses—the substitution and the interstitial—the graphs are obtained which are seen in Fig. 26. The

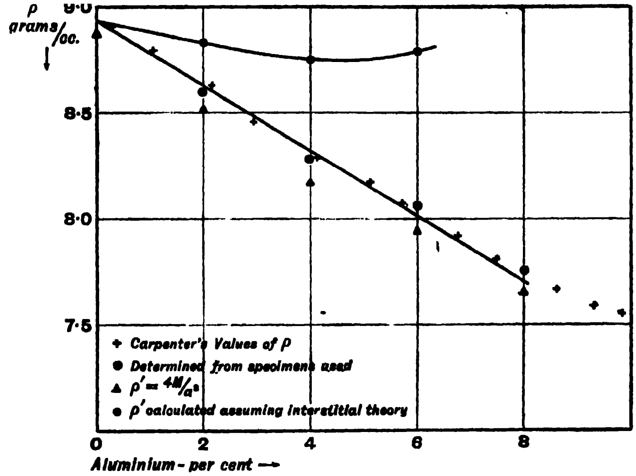

FIG. 26.

density as calculated from the interstitial hypothesis gives the figures of the upper curve—the full dots. The densities as calculated from the substitution hypothesis are indicated by the triangles, and the directly determined densities are given by the straight line, and the points lying upon it, partly from measurements made some years ago by Carpenter and Edwards, and partly from measurements made by Owen and Preston on the actual specimen they used. Although the agreement here is not quite as close as might be expected from experimental accuracy, it is so close as compared with the alternative hypothesis that it leaves no doubt between the two. Actually more recent measurements have eliminated this difference. The two densities agree as closely as can be anticipated, taking into account the fact that no sample of metal used for specific gravity measurements is entirely free from interstices and pores.

If we accept, as I think we must, the substitution hypothesis as being substantially the correct interpretation of the facts in regard to solid solutions, two things must definitely follow, and at least one of them has been experimentally established. In the first place, one atom cannot be replaced by another with exact equivalence. Atom B will not replace atom A and produce upon the surrounding atoms exactly the same attraction or repulsion which atom of A would have done. The consequence is that the other atoms immediately surrounding it, if they remain in their old position, would no longer be in equilibrium, and they, therefore, take up new positions slightly different from the old positions. In other words, the lattice is slightly distorted by the presence of a stranger atom. That distortion must be large or small according to the difference in character between the two atoms. It should be noticed, however, that this is not necessarily a question of the size of the atom. The size of an atom is a very indefinite thing, and this is not a question of packing a larger sphere amongst smaller ones, but it is a question of introducing into an equipoised system of attractive and repulsive forces a centre whose attractive and repulsive forces are slightly different—they may be either larger or smaller than the attractive or repulsive field of the parent or solvent atom. According as the forces are different in one sense or the other, the stranger atom may cause a distortion in the sense of a local expansion or a distortion in the sense of a local contraction of the solvent lattice. If the atoms are extremely similar, the distortion may be very small. If they are very dissimilar then the distortion may be large ; and according as the distortion which the atom produces is large or small, so it becomes possible or impossible to build into the parent lattice a large or small number of stranger atoms without destroying that parent lattice.

One may consider the matter from another point of view—a point of view which is really that of thermo-dynamics—by saying that the distortion produced in a lattice by the introduction of a stranger atom produces a storage of energy in the lattice. There is a certain amount of energy stored by the distortion of that lattice, and the lattice as a whole is capable of storing only a limited amount of energy. When that amount is exceeded there is some alternative arrangement which the atoms can adopt, in which the energy stored is smaller, and that alternative arrangement is immediately adopted—at any rate, if circumstances permit.

The alternative arrangement may be one of several things. It may be a different lattice in which the two kinds of atoms can build together more freely, or it may be a liquid, or it may even be an under-cooled liquid; that is to say, a liquid at so low a temperature as to be quasi-solid. But in any case it is a question of energy content, which of those two things will result, or whether the lattice itself can undergo still further distortion and take up more atoms in solid solution.

We may thus conclude that the first consequence of introducing a stranger atom upon a lattice, is to produce distortion. The second is that the amount of distortion which can be produced is strictly limited, although not perhaps to any definite numerical lattice parameter. There is reason to believe that the actual amount of distortion which a lattice will stand without breaking down depends upon the energy content of the alternative arrangement which is possible. If it is easy to form another lattice, an alternative lattice into which the two atoms can fit more easily than into the distorted parent lattice, then it may be that the lattice will break down with a relatively small amount of distortion. On the other hand, if it is difficult, or if the alternative is a liquid phase of high energy content, then the lattice will have to be very seriously distorted before it will break down. This is where a difficulty arises. If we could say what is the limiting lattice distortion which is possible in any given set of circumstances, it would be possible to write down equations for the equilibrium diagrams of all possible alloy systems. We could calculate the limiting solid solubilities of atoms A and B, or atoms A, B, C, and atom D; but at present those figures are not known, and, unfortunately, X-ray methods do not enable us to determine the limiting distortion which actually occurs when we reach the limits of solid solubility. The X-ray figures give us the *average* inter-atomic spacing, but not the range between maximum and minimum. Perhaps when the methods are further developed it may be possible to arrive at that, or it may be possible to estimate it on theoretical grounds derived from other sources, but at the moment the figures are not yet available, and therefore the full quantitative working out of the consequences of our knowledge that these solid solutions are formed by substitution, and that substitution involves lattice distortion, is not yet possible. We can, however, draw certain quantitative conclusions which are open to experimental verification, and some of those I want now to explain.

The distortion in the lattice may be of two kinds. Generally both kinds will be present. It may happen that this distortion is mainly or entirely local, that it is confined to a comparatively small region round each stranger atom. One hesitates to use figures, but it cannot affect more than a few hundred or thousand atoms around each stranger atom to an appreciable extent. On the other hand, the stranger atom may not produce any local effect at all, but merely cause a general widening or narrowing of the lattice as a whole. Let me explain that by a very simple analogy. If in a pile of india-rubber sheets a number of small steel balls are placed here and there between the sheets, then if the pile is high and a fairly considerable weight is put upon it, the average distance apart of those rubber sheets, the thickness of the pile as a whole, is only very slightly increased, but there is a good deal of distortion of each rubber sheet in the immediate vicinity of a ball which has been introduced. On the other hand, if instead of rubber sheets, steel sheets are used, then there is practically no distortion of those steel sheets in the immediate vicinity of the balls, but the spacing of the sheets as a whole is increased, and the thickness of the whole pile is increased. The first state of affairs—the rubber sheets—is the analogue of local distortion of the lattice; and the second, the steel sheets, is the analogue of general distortion. Local distortion may not even be appreciable by X-ray methods. If the average lattice parameter is not altered, but is only affected locally here and there in the lattice, there will be very little change in the X-ray spectrum. On the other hand, if the average distance is altered appreciably, each stranger atom widens out a whole layer of the lattice. Then there is an appreciable change in the average lattice parameter. This conclusion follows—that where a lattice is stiff and rigid; in other words, when the metal itself is hard (and incidentally that goes with a high melting-point) then there will be general distortion mainly, and not much local distortion; but in a soft metal of low melting-point, there will be mainly local distortion, and not much general distortion. What follows? If the distortion is localised, the maximum possible distortion between any two atoms—the maximum change of distance which is possible before the atoms part company—will soon be exceeded locally, and the lattice will tend to break down locally; so that the number of stranger atoms which can be introduced will be small. On the other hand, if the distortion is general, the actual change of lattice dimensions will be correspondingly slight, because it is spread out over the whole mass of atoms, and the consequence will be that a much larger number of stranger atoms can be tolerated. From that follows the conclusion that it is the hard metals having high melting-points which will, on the whole, tend to form solid solutions of high concentration, and act as solvents capable of taking up a large number of stranger atoms, whereas the soft metals with low melting-point will not be able to do so. Experience verifies that conclusion. Soft metals, such as lead and tin, form scarcely any solid solutions. A slightly harder metal, aluminium, forms limited ranges of solid solutions. Copper forms rather more extensive ranges. Iron forms them freely. Nickel, cobalt, manganese form them freely, and tungsten and molybdenum form them most freely of all. That is a striking manifestation of an inference from the general principles we have laid down.

The limit of solid solubility is of considerable interest from another point of view. In order to understand it, the question of what happens when a soft metal crystal undergoes plastic deformation must be considered. Without going into the whole of that subject, it may be accepted that at any rate a fundamental phenomenon of what occurs is a sliding of layers of the lattice over each other. If one looks at a model of a lattice one sees in various directions layers or planes, and when a crystal built up in that way undergoes plastic deformation, sliding occurs generally on certain of these planes—generally on those where the atoms are most closely packed. In a perfectly regular lattice these are true planes; they are extremely regular, and consequently the resistance to sliding is comparatively slight. If a stranger atom is introduced which causes local distortion the consequence is that these surfaces are no longer plane. In a model (which was shown at the lecture) which represents one quarter of a cube with a stranger atom indicated by a white sphere at what would be the centre of the cube, the kind of lattice distortion that results can be readily seen. The slip planes in the crystal are no longer plane surfaces, but are more or less distorted. The result is obvious—that there cannot be the same ease of sliding on these distorted planes, as there is when these planes are true and uninterrupted. The result is that the introduction of stranger atoms produces a stiffening and hardening of the metal. We know that solid solutions are always harder and generally less ductile than the pure metal; there is a further and very interesting consequence. An atom will produce hardening in some sort of relation to the amount of distortion which it produces in the lattice. The more it distorts, the more it will harden that lattice—the more it will increase the resistance to sliding. We cannot assume any direct quantitative proportionality because we do not know enough about the amount of local distortion, or the influence of a given amount of local distortion on the force required to produce slip; but that there is such an influence, I think we must accept. The extent to which a stranger atom produces distortion locally also determines the number of stranger atoms which that lattice can accept without breaking down, and it follows, therefore, that the hardening effect of an atom and its solubility in the lattice should be roughly inversely proportional to each other, because the more it hardens the more it distorts, and the more it distorts the fewer will the lattice take up. That is an inference which is verifiable from our knowledge of a number of alloy systems, and it can be said at once that in every case which has yet been considered the rule is followed accurately. In the alloys of copper we have nickel, which is soluble in solid copper in any proportions. The hardening effect of nickel on copper is comparatively slight. Zinc, which can only be built on to the copper lattice to the extent of about 30 per cent. by weight has a more rapid hardening effect; 10 per cent. of zinc produces a greater hardening than 10 per cent. of nickel. If we take aluminium, which can only be built on to the copper lattice to the extent of 7 or 8 per cent. by weight, its hardening effect is much greater than that of zinc; and tin has a still lower solid solubility and greater hardening effect. In the alloys of aluminium the same rule is followed. Zinc is capable of being held in solid solution by aluminium to about 30 per cent., and produces comparatively slight hardening, while copper, which is only held to about 4 per cent., produces much more rapid hardening. Iron, which is still less soluble in solid aluminium, produces still more rapid hardening, and so on through many alloy systems the hardening effect is roughly inversely proportional to the solid solubility—not lineally proportional, but they go together in that inverse relationship. That is an important verification of these inferences or ideas. It was the first inference which was drawn, and it meets with striking verification from our knowledge of alloys.

We may now deal with some of the other properties of solid solutions. A pure metal melts at a single temperature. The melting process can be explained in this way:—as the temperature rises the lattice expands. We know it does so, not only because the metal itself expands as a whole, but because X-ray measurements show that the lattice parameter increases proportionally to the expansion of the metal. If the idea, that there is a limiting interatomic distance beyond which the atoms can no longer hold together, is correct, we should anticipate that when the lattice is expanded thermally or otherwise to a certain extent, the atoms would part. If the lattice is perfectly regular, and the interatomic distances are all statistically uniform, they will all part at the same temperature, and the whole of the crystal will melt at a single temperature. If, on the other hand, the lattice is locally distorted, there are some places where the atoms are further apart, and other places where they are closer together, and when a lattice of that kind is heated the limiting distance will be reached sooner at the places where the interatomic distances are large, and later at the places where those distances are small. The result is that melting will commence at a lower temperature and will be completed at a somewhat higher temperature. There will be a melting *range* instead of a melting-point.

It follows that the lowering of the melting range follows upon an expansion of the lattice, and from those ideas it was possible to predict that where a stranger atom causes a contraction and not an expansion of the lattice, it will cause a rise and not a fall of the melting-point. It was, therefore, possible to predict that in such solid solution systems as copper-nickel, silver-palladium, the addition of the higher melting metal would bring about a contraction and not an expansion of the lattice. X-ray measurement has completely verified that anticipation.

It is possible to go further, and to explain at once the composition of the liquid which is produced by the melting of a solid solution alloy. When the alloy commences to melt it will necessarily do so in the case of an expanded lattice in the vicinity of the stranger atoms, because that is where the lattice parameter is largest to begin with. The result will be that the liquid which is first formed will contain more of the stranger atoms than the alloy as a whole. An equilibrium is then established between a liquid containing rather more of the solute with a solid containing rather less. We know from our knowledge of the equilibria of alloys that this is precisely what occurs. On the other hand, if the stranger atom causes a contraction of the lattice it is the lattice in the immediate vicinity of the stranger atom which will melt last, and the liquid which is first formed when such an alloy melts will contain less of the dissolved metal than the solid. There, again, the explanation exactly fits the facts as we know them. Unfortunately, we cannot yet calculate definitely from our knowledge of the lattice distortion what will be the range of melting temperature in a given case, but it may be hoped that in the future we may be able to do that. But on broad lines the facts fit these theoretical ideas very closely.

There is an interesting aspect of this matter which relates to the formation of solutions in general. If a liquid and a solid are in equilibrium, as, for instance, in an alloy of the solid solution type, which is partially liquid and partially solid, there is an equilibrium in a liquid in which the dissolved substance is slightly more concentrated than in the solid with which it is in equilibrium. Suppose that to the liquid is added a little more of the dissolved substance, what occurs? We must suppose that the surface layers of a crystal lattice which are exposed to contact with the liquid will be kinetically exchanging atoms here and there with the liquid. If the concentration of the solute in the liquid is a little too high, the result will be that rather more of the solute atoms will be exchanged with solvent atoms in the solid than in the equilibrium proportion of the solid itself. When that occurs the distortion of the outer layers of the lattice will be increased. That outer layer will then become unstable, and will promptly melt, because the interatomic distance is too high for the temperature, and the consequence is that the equilibrium between the liquid and the solid will be restored by the melting of more of the solid, until the concentration ratios are correct again. Please notice that there is nothing about metals—nothing about any particular substances—in these considerations, so that the argument should be applicable to any crystal lattice in equilibrium with any liquid, and consequently has a considerable bearing upon the general question of solubility. It would seem on these lines that solubility is dependent upon the power of something—an atom, a molecule, or an ion—from the liquid to enter the lattice of the solid and distort it, thus causing the breakdown of the surface layers, and their passage into the liquid phase. That is a perfectly general conclusion which is applicable to all liquids, and not only to metals.

We turn, now, to another aspect of the matter. The manner in which crystals undergo plastic deformation by a process of slip has already been mentioned. In a large model of a face-centred cubic lattice a large number of planes are apparent upon any of which slip is theoretically possible. Experiment shows that as a rule it occurs most easily in this kind of lattice on the octahedral planes.

What occurs when slip takes place? It is quite clear that the atomic bonding, whatever it may be (we do not know much about it) must change over from atom to atom as they pass over each other, because the process occurs without rupture of the metal. Since the slip is large enough to be visible under the microscope, it must occur over literally tens of thousands of the atomic spaces. It seems scarcely conceivable that such movement can occur without causing further disturbance. What occurs is probably that on the surfaces of slip some of the atoms, at any rate, are dislodged from their proper position on the lattice. It may be pictured in this way: a stress is applied to the lattice, and it is, therefore, mechanically distorted by stretching it in certain directions, and when it is stretched beyond the point of possible permissible distortion, the lattice must break down, just as it breaks down when it is stretched thermally, and it melts or forms a different lattice when it is stretched by introducing too many stranger atoms. If, therefore, it is distorted beyond its limit, it must break down under stress also, and it does so mainly locally on these surfaces of slip, and what is formed may, I think, theoretically be regarded as very similar to a liquid layer, that is to say, a layer in which the atomic bonding is no longer regular and uniform, as it is in the lattice. That layer may be thick or thin, but that there must be some such disturbance is a conclusion which it is difficult to avoid.

If that occurs, then after the motion has ceased there is a layer on every plane where slip has occurred which is irregular, and more or less disorganised—what I have sometimes called, and I think rightly, " amorphous " in the sense that it no longer possesses the regular geometrical marshalling of the crystalline lattice. How much that crystalline marshalling has been disturbed, no one knows at present, but that it must have been destroyed to some extent is highly probable.

But something further occurs, and this is an idea, which may be novel, which originated with two of my colleagues, Dr. Hanson and Mr. Gough, in connexion with some work on fatigue. It is that in addition to the possibly thin layer in which the atoms themselves are disarranged there must be a wave of distortion passing through many layers of atoms in the lattice on either side of such a plane of disruption. If the mere fact of replacing one atom by a stranger atom, whose field of force is slightly different, is to produce a large amount of distortion, then the disarranging of a layer of atoms must leave the others under conditions of mutual attraction and repulsion appreciably different from what it is inside the regularly-arranged lattice away from any such source of disturbance. Consequently we should expect to find a distortion of the lattice ranging from perhaps the limiting possible amount to zero at some distance away on either side of a plane of slip. It is that, I think, as much as the actual disturbed layer itself, which accounts for the hardening effect of cold work or plastic deformation in metals. It is not merely that metal layers have been formed in which further slip is impossible or difficult, but the lattice on either side of those layers has been distorted, and this distortion, which Hanson and Gough have called " rumpling " of the lattice, is the main cause of the hardening and is also the cause of the remarkable features of the X-ray spectra, which are given by cold-worked metals. Lattice rumpling must be limited in extent by the law of the limiting parameter, but it is quite sufficient to produce a very marked change in the physical properties of the material. That change, which we know as the result of cold working, is hardening, because the distorted planes offer increased resistance to slip. If the slip mechanism has been hampered or destroyed the metal is able to stand up to much larger forces without giving way, the reason being that in the absence of the possibility of slip the atoms have to be torn asunder and not merely made to slide over each other.

There is another method of hardening metals. A solid solution containing stranger atoms, may, possibly be only slightly harder than the pure metal, if those atoms do not cause a large amount of distortion; but under some circumstances we find that the amount of distortion which a stranger atom causes varies with the temperature. One can understand this by supposing —what is almost certainly incorrect, but is sufficient to illustrate the idea— that some of the atoms expand more rapidly than others, and that, therefore, at one temperature they will pack together better than at another. The real state of affairs must be more complicated than that. The way in which the external field of force of the atom varies with the temperature will be different in different atoms, with the consequence that the relative distortion which they produce in a given lattice will also vary. The result is that in some cases at a high temperature more stranger atoms can be built into a lattice than can be done at the ordinary temperature. If a lattice which is packed to its limit at the high temperature is cooled very rapidly, there is no time for re-arrangement, and the solid solution may be preserved intact—in a metastable condition. The resistance to atomic re-arrangement at the ordinary temperature is too high, and nothing occurs; but if the temperature is raised the superfluous stranger atoms are ejected from the parent lattice, and begin to join together to form a lattice of their own; but in doing so they are bound to disarrange and very seriously rumple the parent lattice, and if there are enough of them, and they are left in an intermediate stage where they have not yet aggregated into large individual groups, and thereby freed the rest of the lattice from their presence, but are concentrated throughout it in small groups, the parent lattice will be distorted throughout to the maximum possible extent, and the result is a metal which is hardened by what we call quenching or tempering, as the case may be. That, I think, is the real explanation of what occurs in the hardening of steel, and it occurs also in the hardening of the aluminium alloys containing magnesium, and in certain other substances. It is simply that a condition is produced in which the dissolved atoms, in endeavouring to rearrange themselves, have been trapped, as it were, in a position in which they cause the maximum amount of lattice distortion. Give them a little more heat and time, and allow them to rearrange themselves a little more comfortably, and much of that lattice distortion disappears, and this is accompanied by softening and increasing ductility, until finally, when the ejected stranger atoms become separated into microscopically visible separate crystals, the substance is practically quite soft again. That is the sequence of events in the tempering of steel and of the aluminium alloys also.

There is another phenomenon in metals which is of considerable interest. The crystals of a solid solution when cooled at a fairly rapid rate exhibit a kind of duplex or "cored" structure. That is due to the fact that the order of crystallisation brings with it a difference of concentration between the outer and inner layers of these crystals. Just as, in melting, it is the most expanded parts of the lattice which melt first, so, on freezing, it is the parts of the metal freest from solute atoms which crystallise first, and those in which the solute atoms are most plentiful crystallise last. The result is coring—an inner core of the crystal which is poor in dissolved atoms, and an outer region which is rich in them; but if these crystals are annealed for any length of time, that difference of concentration equalises itself within the crystal, and this equalisation can take place without any change of the crystal as a whole. The boundaries of the crystals remain much as they were before, but the difference of chemical composition within them is eliminated by diffusion.

With atoms arranged on a crystal lattice, how is diffusion possible? In a liquid we can understand diffusion, because the atoms or molecules are free to move about and change places with each other, but it is almost inconceivable that atoms on a lattice, although they are free to oscillate thermally, should change places. It would mean so large a disruption of the structure that one can hardly imagine that it can occur. There is, however, a mechanism by which diffusion can occur without much lattice disturbance. The application of mechanical stress readily produces sliding, not of a few atoms but of millions of them in layers over each other, and in the softer metals the force required to bring that about is very small indeed. When a stranger atom is present on the lattice, causing distortion, it produces a local stress. The lattice is strained, and there is a tendency, if there are two of these atoms too close together, for them to separate, in order to relieve the excessive strain which they have set up locally; and the suggestion I put forward is that under that stress rows of these atoms—not whole planes, but rows—are able to slide when the temperature is raised and movement is facilitated thereby. The sliding will occur in such a way that rows in different directions will slide simultaneously. It will happen in this way. When a particular row of atoms, owing to thermal oscillations, happens to be in its furthest position, the extra push due to lattice distortion is just enough to swing them over to the next step or equilibrium position. Meanwhile an atom somewhere along that row has swung over into a favourable position, and the extra push swings that whole row—perhaps at right angles to the first—into a new position, and so on, from row to row, until finally the circulation is completed, and the original position of the stranger atom is now filled by one of the parent atoms. The stranger atom is moved on one step. In that way there will always be a tendency for any two stranger atoms to separate until ultimately all the stranger atoms will be uniformly spaced. The diagram shown in Fig. 27 gives a rough idea of the sort of circulation that is suggested, except that in the crystal it would occur in three dimensions.

The idea of such a complicated system of atomic sliding and circulation may, at first sight, appear fanciful, but there is strong evidence to support it. Recently Hevesey tried to determine what he called the rate of auto-diffusion of lead—the rate at which lead atoms could be moved about on their own

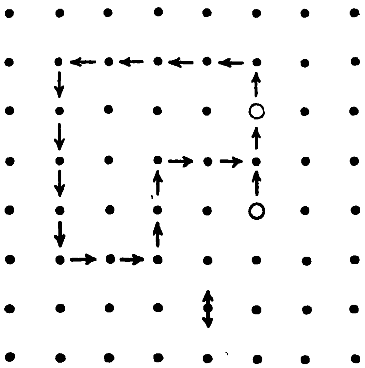

FIG. 27.

crystal lattice. He supposed that diffusion occurs on a crystal lattice in the same way as it does in liquids, by the spontaneous wandering about of the atoms; and he made that measurement, or tried to, by using a radioactive isotope of lead, and measuring its diffusion into ordinary lead. He was astonished to discover that there was no diffsuion—that radioactive lead did not diffuse into lead, although gold could be made to diffuse into lead at the ordinary temperature at a measurable rate. The explanation is obvious. Isotopic lead atoms are so much like the ordinary lead atoms that they cause no distortion of the lattice. Consequently there is no stress tending to cause movement, and however much the lead may be heated, short of melting it, no diffusion will take place.

The theory further indicates that diffusion only occurs in plastic metals. In the case of brittle metals like antimony and bismuth, it is extremely difficult, if not impossible, to obtain diffusion, whereas gold and lead diffuse readily. In the case of crystalline inorganic compounds, which are usually quite brittle, Tammann has shown that diffusion is negligibly small until they are heated to within a few degrees of the melting-point, where one may suppose that parts of the lattice are in a state approaching breakdown so that ordinary diffusion can occur.

These striking facts show that although the mechanism appears a little artificial at first sight, it explains that close connection between plasticity and diffusion which would othersise be inexplicable, and it also explains the non-diffusion of one isotope into another.

I want next to consider the question of what happens where two crystals meet and grow together. If we imagine two lattices approaching each other at a random angle, then they cannot grow together in the ordinary way, except that one atom here and there might be common to both. Even if that were the case, the remaining atoms in the interface which were not common to both would be further apart from each other than the limiting parameter, and they would be free on one side from all direct atomic forces or attachments. The result would be a large distortion of the lattice in each of these crystal boundaries. Actually we note that the cohesion between adjacent crystals is at least as strong, if not stronger, than the cohesion across any of the lattice planes. Consequently, we cannot imagine that there can be fewer atom to atom connections across the crystal boundary than across these planes. If there were, the inter-crystal junctions would be weak and not strong. What is the alternative? There are two possible ways in which the lattices might be united. The one is that they approach each other only within a certain distance, and that between the two there is a kind of transition stage from one orientation to the other. Consider what that means. It means that the lattice in each of the cells of that transition stage would have to be distorted on one side to its maximum extension, and on the other side to its greatest compression. In that case there is a definite maximum radius of curvature which the lattice can assume, and the result would be that the region of transition between two crystals would be comparable in size to the crystals themselves. Microscopic evidence clearly shows that nothing of the sort occurs. There is no such large transition region. The boundaries between the crystals, if not absolutely sharp, are not by any means wide, and consequently the transition theory is out of court if we accept the view of the limiting lattice parameter. The remaining alternative is that between those two lattices there must be an arrangement of atoms in which the maximum lattice parameter is never exceeded, but in which there is no regular crystalline marshalling. The atoms are attached to each other wherever they happen to fit, but not with the complete number of bondings which they normally assume in the lattice. It is true that if it were a question of mere pulling apart, such an arrangement might be weaker than the crystal, but the crystal never fails by pulling apart. It fails by sliding. The boundary can only fail by pulling apart, and when we consider the actual strength of interatomic bonding, which can be calculated from the work done in vaporisation and other physical means, we arrive at a strength of atomic bonding as against direct pull, which is thousands of times larger than the actual strength of metals. So that if in a heterogeneous assembly of atoms—in an amorphous assembly, in fact—the number of bonds which are really attached is only one-quarter or one-fifth of the total, provided that slip is inhibited, the strength would still be much greater than that of the crystal.

We cannot pursue that matter very much further, but it is perhaps worth while to point out that although these ideas of lattice distortion have thrown much new light on many of the phenomena of metals, so far as the conditions at the crystal boundaries are concerned, they appear to me to confirm very strongly the ideas which were put forward many years ago, and which have been supported by much experimental evidence. Enough has now been said to show how far these ideas of lattice distortion, and the limiting lattice parameter consequent upon the substitution structure of solid solutions, go to explain the properties of those constituents of alloys.

One further point, however, also relating to the boundaries of crystals, should be mentioned here. The boundaries which have been discussed are those which exist between adjacent crystals which abut directly against one another after solidification. There is another type of boundary which exists where a solid crystal is formed in a liquid matrix which, later, solidifies as a eutectic. Where, as in a pure metal or simple solid solution, crystals continue to grow until they meet one another, the boundary will take a more or less accidental, roughly polygonal form, without reference to the crystal form or habit of the metal, but when crystals of metal are deposited from an alloy, particularly of a eutectiferous system, one might anticipate that they would assume regular geometrical outlines, being subsequently embedded in the solidified matrix. We find that in some cases they do so, and in others they do not. The reason is fairly obvious from the kind of consideration which has been discussed. Where there is a boundary between liquid and solid it is quite obvious that the atoms forming the outer layers of the solid are not in the same condition as those well inside the lattice. If one can imagine a definite line of demarcation between the lattice and liquid, the outer layers of the lattice would be in a condition in which the atomic forces acting upon them on one side are completely irregular, while on the other side they are more or less regular, but certainly different both in direction and intensity from those ruling within the lattice. The result must be a distortion of the outer layers of the lattice in contact with the liquid, and that distortion will be much more marked at a corner where the atoms are deprived of their normal surroundings, as it were, on two or three sides, than where they are out of their normal surroundings on one side only. If the lattice is a hard, rigid lattice, not easily distorted—in other words, if the metal is one of high melting-point—it may be expected that the distortion does not go very far, and that the natural angles of the crystal tend to be preserved. On the other hand, with a soft and ductile material the distortion may be so great that the corners of the lattice would melt off, and the outlines of the crystal would become rounded. That is a detailed way of explaining what is usually ascribed to "surface tension" between the solid and liquid. The effect really depends on the rigidity of the lattice, which is often strongly marked in inter-metallic compounds forming angular crystals.

NOTES ON BOOKS.

RADIO-EQUIPMENT. By Geo. W. Pepys-Goodchild and Hugh Owen. London: Goodchild and Partners. 1s.

This booklet is intended as an introduction for the novice and a guide for the amateur. "Listening in" is probably the most popular recreation of to-day, and an enormous mass of people are interested in broadcasting. To these Mr. Pepys-Goodchild's book should prove very useful. He gives a full list of all the essential equipment of a receiving station, and advises in a sound and practical way as to the best kinds of apparatus to buy. Further, the prices are given, so that an intending purchaser may know what his expenses are likely to be.

This booklet appears to serve admirably the purpose for which it is intended, and is a most practical handbook for the amateur "listener in."

JOURNAL OF THE ROYAL SOCIETY OF ARTS

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FRIDAY, OCTOBER 23, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

OPENING OF THE 172nd SESSION.

The Opening Meeting of the 172nd Session will be held on Wednesday, November 4th, when the Inaugural Address will be delivered by SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., LL.D., F.R.S., Chairman of the Council.

The subject will be "The Organisation of Scientific Research throughout the Empire." The chair will be taken at 8.30 p.m.

COUNCIL.

A meeting of the Council was held on Monday, October 12th. Present:—Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., LL.D., F.R.S., in the Chair; Sir Charles H. Armstrong; Lord Askwith, K.C.B., K.C., D.C.L.; Llewelyn B. Atkinson, M.I.E.E.; Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I.; Captain Sir Acton Blake, K.C.M.G., K.C.V.O.; Sir William Henry Davison, K.B.E., D.L., M.P.; Sir Edward Davson; Sir Archibald Denny, Bt., LL.D.; Sir Robert Abbott Hadfield, Bt., D.Sc., F.R.S.; Rear-Admiral James de Courcy Hamilton, M.V.O.; Major Sir Humphrey Leggett, D.S.O., R.E.; Sir Philip Magnus, Bt.; Sir George Sutton, Bt.; Mr. Alan A. Campbell Swinton, F.R.S.; Mr. Carmichael Thomas; Professor J. M. Thomson, F.R.S.; Dr. J. Augustus Voelcker, M.A., Ph.D.; Sir Frank Warner, K.B.E.; and Sir Alfred Yarrow, Bt., F.R.S., M.Inst.C.E., with Mr. G. K. Menzies, M.A. (Secretary of the Society).

The following resolution was passed:—

> The Council record with deepest regret, the death of Mr. S. Digby, C.I.E., who served the Society faithfully for thirty-five years as Secretary of the Indian Section, and for twenty-seven years as Secretary of the Dominions and Colonies Section. He earned the affectionate respect of all with whom he worked, and by his zeal and devotion added materially to the successful growth of the Society and to the maintenance of its standard of work.

The Council desire to convey to Mr. Digby's relatives their sincerest sympathy.

Arrangements were made for the appointment of an Assistant-Secretary of the Society.

Arrangements for holding the Third Annual Competition of Industrial Designs in 1926 were considered.

The programme of meetings for the forthcoming session, so far as it is as present completed, was approved.

The Clothworkers' Company again promised £40 towards providing medals at the Society's Examinations.

Other financial and formal business was transacted.

PROCEEDINGS OF THE SOCIETY.

◆

CANTOR LECTURES.

THE INNER STRUCTURE OF ALLOYS,

By Walter Rosenhain, D.Sc., F.R.S.,

Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory.

Lecture III.—*Delivered March* 2, 1925.

We have now to consider the question of the conduction of electricity through metals. The theory of electrical conduction in metals is a subject about which physicists still considerably disagree, but they agree, at any rate upon this point, that electrical conduction consists in the passage of electrons through the metal. These electrons are the minute particles of negative electricity which can exist in the free state. We see streams of them in the cathode ray discharge of a vacuum tube, and in other manifestations. They exist as a kind of satellite to the positive nucleus in the atom, and it is believed, although it has never been proved, that in addition to these electrons which are attached to the atoms in a metal, there are also a number of free electrons. The effect of applying an electric field is to generate in a metal—in a conductor—a flow of electrons. The rate at which the electrons move need not be the rate at which the electric current passes through the conductor. If we apply an electromotive force to a conductor, however long, the effect at the far end makes itself felt after a time which is measurable in terms of the velocity of light. We know that the electrons cannot possibly move through the metal at that rate. It is a question of electrons being pushed in at one end, and a corresponding number being pushed out at the other end, the electrical stress being transmitted with the velocity of light. What the exact mechanism is by which that transmission occurs, and how those electrons behave, exactly, we do not yet know. There are certain difficulties about nearly every theory which can be advanced. One of the earliest theories, and the most prevalent, is that the metal behaves, so far as the free electrons are concerned, as if it were an empty space, and that the electrons move about in it as the molecules of a gas move about inside a closed vessel, and that if additional electrons are pushed in at one end the increased pressure results in a corresponding number being expelled at the other. That seems quite plausible until one looks into the figures, and then it is found that the number of electrons required to carry the current is so great that the other properties of the metal would not fit in with it. The specific heat of the metal would have to be far higher than it really is in order to allow of an adequate number of free electrons. Lindemann has put forward a modification of that view in supposing that between the atoms of the metal in the lattice of the crystal is an independent lattice of electrons, and that when additional electrons are put in at one end by the application of electromotive force, the lattice bodily moves and a corresponding number are expelled at the other end, so that each electron has moved only one interatomic distance. Unfortunately, it can be shown mathematically that an electron lattice between the atoms would be unstable and could not exist. There are other objections also. However that may be, the fact remains that electrons must in some way or other travel through, or rather communicate their motion through, the crystals of the metal, and it at once suggests the idea that where the crystal of the metal consists of atoms perfectly regularly arranged on a lattice, the passage of those electrons through that lattice, either through the atoms or between them as the case may be (we do not know which it is), will be very little, if at all, impeded by the atoms ; but where the atoms are not in line, where they are out of line, either through thermal oscillation or through the distortion of the lattice by the presence of atoms of another kind, there the motion will be impeded, and part of the energy of that motion will be dissipated as heat. This can be illustrated by a very simple mechanical analogy. Consider a number of elastic spheres resting upon a perfectly smooth, frictionless plate, perfectly aligned one with the other ; if an additional sphere is pushed against the end of the row with a certain amount of impact, one of the spheres at the far end will, after the slight lapse of time required for the passage of the elastic wave, be expelled from the row. The sphere at the other end will emerge with precisely the energy which has been put in at the beginning, assuming that the spheres are perfectly elastic, and that there is no friction. A number of billiard balls on a smooth billiard-table are a fairly good approach to that state of affairs.

If, however, instead of a perfectly straight row of equal spheres, we have in that row of spheres, let us say, one larger one, the conditions are altered. The first case is one illustrated diagrammatically in the upper diagram of Fig. 28, which corresponds to perfectly frictionless and non-dissipating transmission. In the second row a larger sphere is interposed. If an impulse is sent through that row of balls in the total absence of friction, the middle sphere will receive

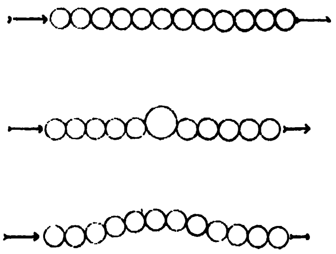


FIG. 28.

its blow not strictly in line with the others ; there will be a lateral component of the blow sent which reached that particular sphere, and part of the energy of the blow, instead of being transmitted along the row of balls, will go towards moving that sphere laterally—or tending to do so. A certain amount of energy will be dissipated at that point. It is not necessary to have a larger sphere. If the balls are not perfectly in line, precisely the same thing will occur, because the transmission is no longer perfectly diametrical through each sphere. There is a lateral component. Although that is only a rough mechanical analogy, it applies to this extent—that where electrons move through or between the rows of atoms, if those rows of atoms are perfectly rectilinear the energy of the electron will not be affected, because the impulse from atom to atom is in the direct line of transmission ; but where the atoms are displaced from their rectilinear position, there the atoms themselves will be set in motion at right angles, more or less, to the path of the electron current, and that motion is actually thermal oscillation, and part of the electrical energy will be degraded into heat energy, as in the passage of electricity through ordinary conductors. That idea was put forward by Lindemann a good many years ago, although at that time we did not know, as we now know, exactly how the atoms are arranged in the crystal. If we had the atoms of a perfectly pure metal in a perfectly arranged crystal, and freed them entirely from thermal oscillation, we should anticipate that there would be no resistance to the passage of electrons. In certain metals that is the case, as Kammerlingh Onnes has shown. In some metals, notably lead, when a temperature not more than five or six degrees above absolute zero is reached, the resistance to the electrical current becomes zero, and the current, once started in a ring of very pure lead at that temperature will continue substantially undiminished for days or even weeks. That is the well-known phenomenon of super-conductivity. But if the theory which I have suggested were the whole story, we should anticipate that this would occur in all pure metals. We should not anticipate that it would ever occur in an alloy, and that, at any rate, is true. But super-conductivity does not occur in all metals. There are only certain groups of metals occupying definite positions in the periodic table of the elements which appear to be capable of assuming the super-conducting state, and it follows that there must be some resistance to the passage of the electrons through or between the atoms depending upon the nature of the atoms or—perhaps it is better put in this way—upon the nature of the interatomic linkage. Where that linkage is of a certain kind, probably depending upon the number of electrons in the outer shell of the particular atom concerned, there the passage is free, and super-conductivity is possible. With other electron arrangements the passage is not free. A certain dissipation of energy occurs even when thermal oscillation is entirely absent.

Thermal oscillation, it should be noticed, need not be entirely absent to allow of super-conductivity. It is only necessary that it shall fall below a certain low limit, because if at any one instant there is a single row of atoms in a crystal fully in line, and if such a line offers no resistance to electrical conduction, that single row of atoms is capable of carrying the whole of the current. The material will behave as a super-conductor in spite of the fact that the other rows of atoms are slightly displaced. That is why super-conductivity sets in at a temperature appreciably above absolute zero. Whether it would occur in all metals *at* absolute zero we do not know. At any rate, this conception of the distortion of the atomic lattice by thermal oscillation accounts for the behaviour of metals in this respect—that their conductivity at very low temperatures is exceedingly low—in some cases nil—and that their conductivity diminishes rapidly with rising temperature, because the rows of atoms are increasingly distorted by thermal oscillation.

In alloys there is a different state of affairs. There the rows of atoms can never be perfectly rectilinear, even at the absolute zero, and therefore electrical conductivity can never be infinite. On the other hand, the disturbing effect upon the lattice of a given amplitude of thermal oscillation will be relatively smaller than when the atoms are otherwise regularly arranged. If a row of atoms is already distorted slightly, and the atoms are then made to oscillate through a certain amplitude, the total want of alignment of those atoms with a given amount of thermal oscillation, although it will be slightly greater than in the absence of such oscillation, will not be so much greater than in the case of an undistorted row, where the disturbance would be nil if there were no thermal oscillation. That means that in a solid solution the effect of temperature in increasing the electrical resistance will be smaller than it is in a pure metal. That, of course, is a very well known phenomenon. It is actually possible to obtain alloys in which the change of electrical resistance with temperature is nil, and in a few cases it is slightly negative. In these cases there are countervailing effects, where the degree of distortion due to the stranger atoms diminishes with rising temperature more than the disturbance due to thermal oscillation increases the irregularity, so that the total irregularity may actually diminish on a rising temperature to a slight extent. In some cases the two effects will balance exactly, and the result is an alloy like manganin or ohmal, in which the temperature co-efficient is exceedingly small.

There is one other interesting fact which might perhaps be mentioned here, although it has no bearing upon electrical conductivity, and that is, it is not only the electrical impulse passing through a row of atoms which will give rise to heat and dissipation of energy if the row of atoms is not perfectly straight. If a load is applied to a piece of metal the stress due to that load is transmitted through the metal as an elastic wave. There is no other way in which it can be transmitted. That elastic wave means a transmission of energy from atom to atom. When the atoms are perfectly in line, we would expect that the transmission of energy would be free from dissipation; in other words, the stress would travel down that piece of metal without generating any heat—without any loss of energy or work. But where rows of atoms are not perfectly regular, there must be a certain amount of lateral vibration set up in the atoms by any wave passing through them. The result is the well-known effect of elastic hysteresis—that when a load is alternately applied and removed and applied a certain amount of energy is dissipated in spite of the fact that no permanent change of dimensions of the piece of metal is produced. Apparently no permanent mechanical work is being done on the metal, yet a small amount of energy is being dissipated, and I think the explanation lies in the fact that during the course of transmission, owing to the fact that the atoms are not perfectly in line, a certain amount of lateral vibration is set up among the atoms.

I want now to pass to another type of consideration. We have so far thought of a distorted lattice as if the distortion was purely a question of the geometrical displacement of some of the lattice points, and consequently of the atoms which are situated upon those points, thinking of the atom as an indivisible and rigid whole. But we know that the atom is not a perfectly rigid and indivisible whole, but that it is a complex system of electrons revolving about a nucleus or proton, and that it is very far from being rigid. It can be distorted. It can actually be compressed mechanically.

We do not know at all what is the bond or linkage between atom and atom in a crystal lattice, or in any other form of aggregate. We scarcely know even in the case of chemical compounds. But there must be some transmission of force, some linkage between the atoms, by which the cohesive forces act. If an atom is pushed forcibly out of its normal position, it is quite evident that wherever those linkages are applied, wherever in that complex system (which the atom really is) those forces act, they will not only displace the atom as a rigid whole, but they must distort the atom itself to a certain extent. By distortion of the atom, I think it is best to picture a slight displacement of the orbits of some of the electrons. We must picture the electrons moving normally in regular orbits of some kind, and the effect of pushing an atom out of its position must be to displace, to some extent, the electron orbits in the atom—perhaps only the outer electron orbits. Possibly the effect may be more deep-seated even than that. If that is the case, the effect on the atom must be very marked in certain respects. Take, for instance, the question of the optical behaviour of an atom. The modern theory of radiation shows that radiation depends upon changes in the electron orbits. The electrons appear to be capable of jumping from one orbit to another, and in doing so give out radiant energy, the amount being a definite quantity or "quantum." A given atom is capable of radiating light of a certain wave length. If it is excited suitably—the most usual way of exciting it is by heat, but it can also be done electrically and in other ways—it is quite conceivable that it might be excited to radiate at the ordinary temperature. If, instead of that, light waves fall upon it, it is capable of absorbing light of the same wave-length as it would radiate if excited, and if it has certain particular frequencies which it can radiate, it will also absorb those frequencies. If that is the case, the reflected light from a crystal made of such atoms will have a definite colour. In metals the colour as a rule is not very marked; in other words, the selective absorption of the atoms is not as a rule very pronounced, although when we come to study them closely metals all have distinctive colours, but in a few cases, such as copper and gold, we have strongly marked colours, due to the absorption particularly of the blue waves. Now, if an atom of that kind is distorted in any way, the first effect one would expect to find, if the modern views of radiation are correct, is a change in the frequencies of radiation which that atom will emit or absorb. In other words, the first effect of that distortion will be a change of colour in the material. Here we touch upon a subject which has been studied perhaps less than any other property of alloys, and that is their colour. The theory of lattice distortion and of consequent slight atomic distortion helps to clear up to some extent this problem of the colour of alloys. It is a very remarkable property, because if a strongly coloured metal like copper has other metals added to it, something like 60 per cent. of zinc can be added before the colour is entirely removed—before the metal becomes approximately white. On the other hand, 15 per cent. of nickel is quite sufficient to discharge the colour entirely. Other metals produce effects in other proportions What is the reason ? The reason at any rate for some of the phenomena is given by the distortion theory. Some of the most striking cases are alloys of copper and zinc. We have in those alloys a series of solid solutions. There is first of all the α solid solution which ranges from pure copper to about 30 per cent. by weight of zinc. Then follows a region in which the β constituent, also a solid solution, makes its appearance, and finally, a little further on, the alloys are completely composed of the β constituent. What happens in regard to the colour ? As atoms of zinc are introduced into the α copper lattice, that lattice is expanded and distorted, and consequently if the ideas here suggested are correct, the copper atoms will be correspondingly distorted to a successively increasing extent as the concentration of zinc in the α solution increases. In accordance with that, we find that the red colour of copper is rapidly changed; nearer the limit of saturation of the α solid solution the alloys show a greenish yellow, which is typical of such material as the ordinary 70/30 brass. Comparison of these colours, however, requires care, because what one sees in the ordinary way are thin oxide coatings which affect the colours appreciably, but a freshly-cut surface gives a very good idea of the true colours.

But what happens when the content of zinc is increased a little further? The α lattice cannot be distorted any further, and therefore what occurs is the formation of a new lattice. The reason why a new lattice is formed is that the total distortion when there are rather more than 30 per cent. of zinc by weight present is actually less on this new lattice than it would be if more zinc atoms were fitted into the original lattice. If the distortion of the whole lattice is less, then the distortion of the copper atom also is likely to be less. Consequently one would expect, on the view I am putting forward, that the colour should revert—that there should be a step back in colour as if one had gone back towards the copper end of the series. And that is actually the case. It becomes most marked at the point where the alloy consists entirely oi the β body. On the table are a number of samples of copper-zinc alloys ranging from about 30 per cent. down to about 54 per cent. of zinc. These colours are not very well seen in artificial light, but if in daylight when they are freshly cut, one sees at once that the yellowest of the alloys contains only 30 per cent. of zinc, and that as the content of zinc rises up to the point where the pure β brass is reached there is a distinct reddening of the alloys. Then, as more zinc is added, the colour changes towards yellow again, and there is a second slight step back when the β phase is reached. There are many other phenomena connected with colour. I am not prepared with explanations of all of them. The whole subject has scarcely been studied yet, and the present ideas are suggestions rather than established explanations. It is interesting to find, however, that in the case of nickel, where the change of colour is so very marked, the explanation may be that nickel compresses the copper lattice when zinc expands it. It is not very difficult to imagine that when the atoms are pulled closer together there is more distortion of the atoms themselves than if they are pushed apart. When the atoms are pushed apart the distorting effect will be mainly concentrated in the neighbourhood of the alloying atoms, but when the whole lattice is closed up there must inevitably be a certain amount of squeezing up of all the atoms and a resulting distortion of the electra orbits. That may be the reason why the effect of nickel on the colour of copper is so much greater than that of zinc.

A somewhat similar effect attaches to lattice compression in connection with electrical conductivity—that where distortion is accompanied by compression of the lattice, the effect on the electrical resistance is generally much greater than where there is an expansion of the lattice. Although the lattice may be made less regular, or perhaps equally irregular, by expansion as by contraction, the mere fact of contraction seems to bring with it a much greater effect upon the physical properties. If one can imagine the electrons having to pass between the rows of atoms, one can see at once why that should be so; but these details will have to be worked out with much greater accuracy, and with more detailed knowledge of the exact effect of each metal upon the other, before we can be certain that explanations of that kind are really justified. For the moment they show the way in which these views of the inner structure of alloys help us to form ideas as to the mechanism of the known changes of properties.

Distortion of atoms as the result of alloying may affect the properties of metals in other ways than in regard to radiation. One of the most mysterious properties of certain metals is magnetism. Modern views of magnetism suggest that it is connected with a certain want of symmetry in the structure of the atom itself; that a certain unbalance between the electrical forces within the atom leaves a residual effect which is the cause of the magnetic phenomena. If that is so, it suggests at once that any distortion of the atom, as the result of lattice distortion, may have a disproportionately large effect upon the magnetic behaviour of the material, and we actually find that even elastic strain, and certainly plastic strain, produce profound changes in magnetic properties. The magnetic property, for instance, of a soft iron or a silicon steel transformer sheet can be seriously injured by applying a small amount of cold work to it. Far more effect is produced on the magnetic properties than on the mechanical properties, with the possible exception of actual hardness. The interesting feature about it is that apparently the effect of alloying atoms may be either to improve or deteriorate the magnetic properties. That seems to depend upon the kind of atom that is introduced. If, into commercial iron, for instance, atoms of silicon or aluminium are introduced in solid solution, the magnetic properties as a whole are improved, certainly the permeability is improved, and the hysteresis loss is diminished. The reason may be that in commercial iron there is a sufficient number of injurious stranger atoms present to produce a certain degree of initial distortion, and when these other atoms are added, the distortion they cause is opposite in sign to that which is present already. The total distortion of the lattice may thus be relieved and therefore the total distortion of the atoms. A very interesting discovery has been made recently in America; this is a highly magnetic alloy containing 79 per cent. of nickel and 21 per cent. of iron, approximately. That material known as "Permalloy" has most remarkable magnetic properties. Even in the weak magnetising field of the earth it is very nearly magnetically saturated. As an inductive loading for cables it is proving extraordinarily valuable. That material has one most striking property. If its magnetic properties are determined in the annealed condition, and a very small amount of plastic deformation is applied to it, its magnetic properties are very much altered. The change is not a matter of one or two per cent., but of hundreds per cent. That is a very remarkable fact. The explanation I would suggest for it, on the lines which I have been indicating here, is this: in that alloy we are not dealing with an intermetallic compound, but with a solid solution system, in which the atoms are probably arranged in some special manner. There seems to be some special way in which the atoms can group themselves on the space lattice, so that the mutual distorting effect puts all the atoms into the most susceptible magnetic condition. But if in a crystal built up in that way we cause sliding of layers over each other, even if the sliding goes only a very little way, it is evident that any peculiar geometrical arrangement will be destroyed and layers will be produced in which the iron and nickel atoms so far from being in their best magnetic condition, are in a comparatively very bad magnetic condition. Hence the enormous effect of slight mechanical work on an alloy of this kind. It may be possible to obtain a similar arrangement of the atoms in non-magnetic alloys forming solid solutions. Tammann has worked on this subject, and believes he has discovered certain chemical properties in the alloys of gold and silver particularly, which he ascribes to the geometrical regularity of spacing of the gold and silver atoms. X-ray study has not, however, confirmed that idea. Probably the time which was allowed for the atoms to arrange themselves by the annealing of those alloys has been insufficient to give any hope of obtaining a symmetrical atomic arrangement. If we succeed in preparing a solid solution, in which the atomic ratio is suitably adjusted, in a condition in which the atoms are not only in physico-chemical equilibrium, but in geometrical equilibrium, in which geometrical uniformity is achieved, the product will be a solid solution of a very peculiar kind. In it there will be no lattice distortion (because the arrangement will once again be symmetrical), and consequently we should have an alloy with a single melting point, and having a good electrical conductivity and low hardness. Experimentally that has not yet been done.

In a system like copper-nickel, there is a continuous series of solid solution alloys in which the range of melting point apparently increases up to the middle of the system and then decreases again. But there is reason to think that if instead of determining the solidus in alloys cooled at ordinary rates, very slow cooling is allowed so as to give the alloys a chance to reach something more like final equilibrium, it will be found that the solidus shows an upward bend, and it is not too much to hope that by sufficiently slow cooling or prolonged annealing it may be possible to realise a condition in which these two curves (liquidus and solidus) meet, and in that case we should have a truly symmetrical solid solution. Such a material would be electrically the exact analogue of permalloy in the magnetic sense. In other words, it will be a material of low electrical resistance which will be made very highly resistant by a very small amount of deformation. That, at present, is merely a prediction from theory. It remains to be verified. It is experimentally very difficult to realise and has not yet been accomplished.

It may be asked whether a symmetrical solid solution of that kind is not really an inter-metallic compound. I think the answer is No, because it is perfectly possible to destroy the symmetrical structure without altering many of the characteristics of the material, and in that respect we have something distinct from an intermetallic compound. On the other hand, typical intermetallic compounds are found not only to correspond with maxima on the liquidus of the corresponding equilibrium diagram but, under X-ray analysis to show a lattice structure quite different from that of a pure metal or a solid solution.

A typical inter-metallic compound is the body $CuAl_2$, samples of which have already been mentioned. Its lattice structure is shown in Fig. 29.

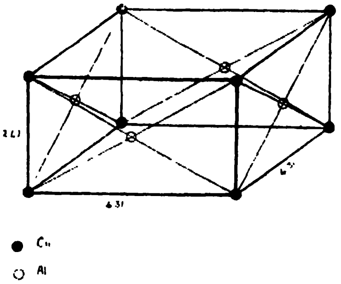


FIG. 29.

The black spots represent the copper atoms, so that the diagram of the unit cell looks as if it contained far more copper than aluminium atoms, but each of the corner atoms belongs to eight cells, and each of the aluminium atoms belongs only to two ; so that the true ratio is two aluminium atoms to each of the copper atoms if we take the structure through a large mass. In this compound, however, we have a lattice which is 4.31 Ångström units wide and 2.42 high. That 2.42 is much less than the normal interatomic distance of two copper atoms. What happens is, apparently, that the aluminium atom has absorbed something—presumably electrons—out of the copper atoms, which has reduced their effective size and allowed them to come much closer together. With a body like that it is not possible to re-arrange the atoms by sliding them over each other in layers without destroying the whole system. Actually that body is completely brittle. It is incapable of undergoing slip, which is one of the most characteristic features of these somewhat irregular lattices of intermetallic compounds.

It is quite obvious that in such a lattice it is not possible to replace an aluminium atom by a copper atom and still retain that arrangement, because the very thing which enables the two copper atoms to keep so close together is that something has been taken out of them by the adjacent aluminium atom. A copper atom in its place could not do that, and the result is that this substance should have no power of holding copper in solid solution. Whether it might hold a little aluminium in solid solution by replacing some of the copper atoms by aluminium is not so certain, but it is unlikely. At any rate, the solution-forming power of intermetallic compounds is always very small, and in that they differ intrinsically from solid solutions.

The lattice structures of some other intermetallic compounds have been determined by Owen and Preston at the National Physical Laboratory; they are shown in Fig. 30. On the left is the compound Mg_2Si, and on the right the compound AlSb. These structures show interpenetrating lattices of two kinds of atoms, but it is clear that no displacement is conceivable without complete destruction of such a structure. Again, replacement of one kind of atom by the other would be difficult owing to the fact that the mutual arrangement is dependent upon an interchange of electrons, which would not be possible if one of those atoms were replaced by one of the other kind. It might be possible to replace them by another kind of atom; for instance, magnesium might be replaced by some other element somewhat like it. None the less the solvent power of a compound must necessarily be very slight if it exists at all. Also a compound thus constructed could hardly find its place on the lattice of a parent metal. In other words, if that substance dissolves in another solid metal, either magnesium or silicon or aluminium, it can only happen by the atoms taking up their places on the lattice of that solvent as individual atoms, and not in the particular complex interpenetrating arrangement which is shown in the figure. That may not be universally true. For instance, in the case of carbon and gamma iron it is probably not true, but in the great majority of cases it is probably right to say that when an intermetallic compound passes into solid solution it does so in the form of dissociated atoms. We should not, therefore, speak of, for instance, $CuAl_2$ passing into solution in copper. What we have is a solid solution of aluminium and copper from which that compound may crystallise out. It is almost certain that the compound does not exist as such in the solid solution; if it did X-ray analysis would indicate its presence.

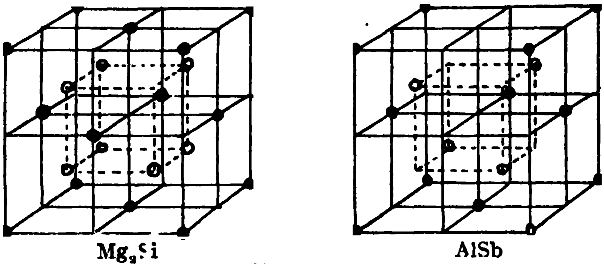

Mg_2Si AlSb

FIG. 30.

In some alloy systems, like the copper-zinc system, there is a succession of solid solutions. Right through the system we find the alpha-beta-gamma bodies, etc., and the view has been held that those are in reality intermetallic compounds capable of dissolving both zinc and copper. We have seen that this is improbable, and the fact that we have these continuous ranges suggests that what we are dealing with there are not inter-metallic compounds, but rather what I may call allotrope lattices. The alpha lattice of copper is the normal lattice of the copper atom—not necessarily the only possible lattice upon which that atom can be arranged, but so long as it is convenient, so long as the energy conditions allow of it, additional atoms of zinc replacing copper are simply built on to that same face-centred lattice. But when the number of zinc atoms increases beyond a certain point, what I believe occurs is that the copper atoms themselves change over into a different lattice arrangement upon which they can accommodate a larger number of zinc atoms. In other words, the copper lattice accommodates itself a little to the zinc lattice, and in the β lattice of the copper-zinc system we have not the face-centred cubic arrangement, but the body-centred arrangement. It is sometimes shown as if the zinc atom were the atom at the centre of the cube, but we have no justification for thinking of it in that way; in fact, the very way in which zinc diffuses through these alloys suggests that it can find a place upon any of the lattice points indiscriminately in the ordinary way. What we really have is a copper lattice which is an allotropic form of copper, kept in that condition by the presence of a sufficient number of zinc atoms, and when the number of zinc atoms is still further increased we have the γ body, where a still different lattice is formed; and finally when we approach the zinc end of the system we find the close packed hexagonal lattice which is really the lattice of zinc itself.

We have thus four or five different lattices across the system, none of them due to the formation of any definite chemical compound, but merely a mutual arrangement between the two kinds of atoms. That type of system is by no means uncommon in alloys.

It will not be possible to carry the discussion of intermetallic compounds and solid solutions much further; enough has perhaps been said to show the general considerations which the theory of lattice distortion implies. To some extent that theory is at present in a tentative condition, requiring quantitative confirmation in many directions, but it is beginning to receive that quantitative confirmation in a few places.

As regards the ultimate bearing of these things, if we could settle definitely what are the limits of lattice distortion—what are the real facts about mutual replaceability of atoms—then it ought to be possible to understand the exact reason why a particular pair of metals forms an alloy system giving rise to this, that or the other equilibrium diagram. We ought, in fact, to be able to predict from a knowledge of the atoms themselves the kind of configuration which mixtures of these atoms will produce. We can do so now in a general way. We can say that solid solution will result where the solvent metal is a hard metal, and that the solid solutions will have a greater range, the less the dissimilarity between the dissolved atom and the solvent atom, this similarity being not only a question of atomic volume but of similarity of atomic force field. It may be associated with size, but size may prove to be one of the least important factors. We can say when we have a soft metal that we cannot expect to dissolve in it in the solid state any large amount of another metal, and that clears up, at any rate, one of the fundamental difficulties about an alloy system. It enables us to predict with considerable certainty the kind of system which any two metals will form. If we could carry that further, and predict quantitatively that when two given metals are mixed together they will form a solid solution up to a certain concentration, and then they will form either another solid solution over another range of concentrations, or will form an inter-metallic compound incapable of forming solid solutions, then the whole key to the mystery would be in our hands. But we have not arrived at that stage yet, although we may reach it before very long.

The fact that there is a regularity governing the alloy systems is very plain. It was pointed out some years ago both by Professor Desch and by Professor Carpenter. In Fig. 31 we have an illustration of one of those features.

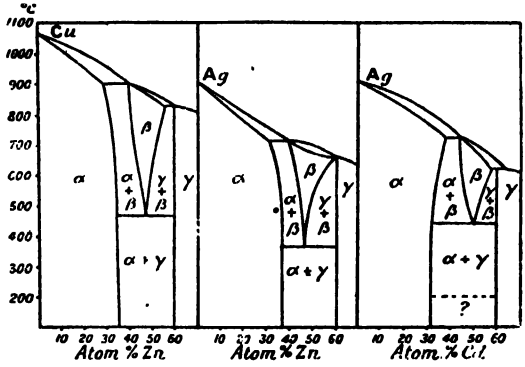


FIG. 31.

The figure shows portions of the equilibrium diagram of three groups of alloys of copper, and silver with zinc and cadmium. It suggests that the relation of the cadmium atom to the silver atom is very much the same as that of the zinc atom to the copper atom. When the known facts about these atoms are considered that suggestion is borne out. Those similarities between alloy systems exist to a much greater extent than we realise at present. If we plot our equilibrium diagrams to a distorted scale, so as to compress a long range of solid solution in one and expand it in another, and if we allow for the effect of the atomic characteristics of the individual metals, then we could recognise similarities which at present, by our ordinary methods of plotting, are not recognisable. They undoubtedly exist, and it may not be very long before metallurgists are in a position to predict the properties of alloy systems, and perhaps to carry that process of prediction far beyond the limits of experimental study. We can study binary alloys. We can study with much labour and expense a ternary system. Some few have even ventured upon the study of small portions of ternary systems, but unfortunately, the practical man will not be content with these. He puts five or six metals into his pot, to obtain something which he thinks is super-excellent. Whether he is wise in doing it I do not know. Perhaps it is possible to avoid those complications. Even if it is, it is desirable to understand them. We certainly cannot do so by diagrams and models in the ordinary way, and systematic study is a labour of many lifetimes when it comes to systems of five or six metals. Our hope, therefore, must lie in an understanding of the fundamental facts and laws, and I hope the ideas which I have tried to explain may at any rate, if they are not themselves the key to that complexity, lead others to find that key.

OBITUARY.

Brigadier-General Henry Norlande Ruttan, C.M.G.—Brigadier-General H. N. Ruttan, who was elected a Fellow of the Royal Society of Arts in 1910, died at Winnipeg on October 13th. He was born at Cobourg, Ontario, in 1848, and qualified as a civil engineer. In 1865 he entered the Canadian Militia, and served against the Fenians in 1866, and against the North-West Rebellion in 1885. He was for many years city engineer of Winnipeg, and he took part in the construction of the Inter-Colonial and Canadian Pacific Railways. He was president of the Canadian Society of Civil Engineers in 1910, and was also a member of the American Society of Civil Engineers.

CORRESPONDENCE.

PRONUNCIATION OF SCIENTIFIC TERMS.

May I call the attention of the Fellows to the remark on page 1,021 in the review of "A Treatise on Light," by R. A. Houstoun—"It seems admirable as a school book, or a general reading book"?

The Lecture on the Inner Structure of Alloys (by Dr. Walter Rosenhain, F.R.S.), with its lucid description of Atoms and Crystals, would also make a desirable reading lesson, if it were possible for the ordinary student to pronounce the technical terms of any science.

The printing of the words Ångström units (page 1,019) proves the feasibility of adopting the Orthotype Notation in the *Journal*.

As such a simple word as "metallurgy" in ordinary print can be, and has been, logically pronounced "meet-all-your-guy," one can imagine what the reading aloud of this treatise would sound like.

The cause of unemployment is largely the ubiquitous German traveller, who has been trained by a phonetic print. That the English printer has no means of indicating his own, or anybody's speech sounds is surely a disgrace to all interested in that art which is preservative of so many other arts—Print.

A. Deane Butcher.

NOTES ON BOOKS.

Louis Pasteur. By S. J. Holmes. London : Chapman and Hall, Ltd. 7*s*. 6*d*. net.

The author, who occupies the chair of Zoology in the University of California, devotes his first chapter to the home life, ancestry and ambitions of Pasteur, while the second chapter touches on Pasteur's work in the old or usual aspects of chemistry and physics, work in which he was more or less associated with many eminent investigators, as, for example, Dumas, Claude Bernard, A. Laurent and Biot.

Chapter III. (pp. 41-60) is addressed to persons of slender knowledge, by way of preparing them for an understanding of Pasteur's later and more important work, and it also aims at a popular exposition as to " The World of Microscopic Life," a chapter we may regard as less satisfactory than some other parts of the book, as there are traces of that inexactness as to fundamental aspects which it is easier to tolerate in a newspaper than in a volume like that before us.

For example, a paragraph commencing on p. 52 and ending on p. 53, refers to a bacterium, which can divide an hour after its own natal fission, and the hypothesis as to reproduction in a continued and exact geometrical ratio is so applied as to lead the imagination to a progeny forming a mass of closely packed bacteria, which in four days and a half occupies a volume "——more than equal that of the entire Pacific Ocean ! " As the inevitable inhibitory agencies are not even suggested, the person of slender knowledge, to whom this chapter is addressed, may be led to think that the world is in danger of being suddenly dominated by a strain of pathogenic bacteria ; moreover, that all (or nearly all) bacteria are pathogenic or malignant.

The author, in the subsequent or main chapters of his book, treats very cleverly and pertinently of those characteristic habits of thought, work, and influence over others, which mark Pasteur as one of the great men of the nineteenth century. For example, on p. 91 we read how by tilting a flask (or two) and making deductions from consequent events Pasteur proved Schwann's vitalistic theory of putrefaction, and demonstrated the real value and function of the cotton wool plug of Schroeder and Dusch, also of the drawn out and tortuous neck of Hoffmann and Chevreul, Pouchet's contentions being at the same time finally proved to be untenable.

The general account of the work of the Pasteur Institute, both before and after Pasteur's death, is so interesting and to the point as to give special value to the book.

Why the Weather ? By Charles Franklin Brooks, with the collaboration of John Nelson and others. London : Chapman and Hall, Ltd. 8*s*. 6*d*.

Mr. Brooks is Secretary of the American Meteorological Society, also Associate Professor of Climatology in the Clark University, and a course of his lectures having been attended by Mr. John Nelson, this gentleman published very full reports in his newspaper. A widespread interest in the subject resulted ; illustrations and new facts came to hand ; also new ways of regarding old facts. The outcome is an attractive volume, fully illustrated and indexed ; but rather a departure in style and arrangement from all the treatises on meteorology with which we are acquainted. The concise wording is easy to read and understand ; many things not formally stated being pleasantly suggested so that, open the book where one will, new trains of thought are stimulated.

On p. 6 we find Christina Rossetti's lines :—

" Who hath seen the wind ?

Neither you nor I,
But when the trees bow down their heads
The wind is passing by."

The author next points out how much we can learn as to the direction of wind, its speed and other matters in an approximatively quantitative sense, by thoughtful observation of vegetation and every-day objects.

Opposite this page (6) is an inset plate, on the two sides of which are photographs of, and notes upon, some of the more important measuring instruments, e.g., mercurial barometer, aneroid barometer, aneroid barograph, sling psychrometer and hair hygrograph.

The chapter on summer weather (pp. 97-118) gives rules of action and reasons why in relation to hygrometry as bearing on weather from northern Minnesota to Florida, and we read of streaming walls and cellars, which are wet by water condensed from the atmosphere - troubles of which we have comparatively scant experience in Great Britain. This chapter appropriately concludes with a ready method of finding the dew-point. A mixture of tepid water and ice is stirred by a thermometer in a tin cup till the outside of the cup is clouded, and the reading of the thermometer is then taken. Another more detailed study of this test, in its relation to thunderstorms, is to be found on p. 147.

Section X., Mountain Weather, and Section XI., Thunderstorms, present many aspects of interest which hinge on the magnitude and variety incidental to America; while Fig. 24, a theoretical cross-section of a thunderstorm, links together many concepts, and appears to bear in an interesting manner on the views as to thermal stratification put forward by Dr. Simpson at the recent meeting of the British Association (*Nature*, August 29th, 1925, p. 339: also September 5th, p. 361).

The publishers are to be congratulated on the introduction of the present work to Great Britain, and it should be welcomed by the general reader as giving him broad views at one reading, by the young student of physical science as giving him material for integrating with his studies in other branches, and by the matured meteorologist as giving him new directions for thought, investigation and arrangement.

THE RIDDLE OF THE EARTH. By "Appian Way." London: Chapman and Hall, Ltd. 10*s*. 6*d*. net.

The view that the earth was at one time a white hot fused mass, and that we dwell on the solidified surface --the interior being still in its original fluid state—is rejected by our author as untenable.

His view, as we understand it, is that the earth, as a whole, has been solid from the beginning, and that it has increased by occasional additions from the outer cosmos, these additions not only bringing solid matter, but also air and water. A large meteoric or cometary addition coming at high speed and with some approximation to normal incidence may, perhaps, account by impact for such heat as might have produced a lake or area of fusion, or a volcano, or a volcanic district.

As the result of this theory and the way that the author illustrates it by natural phenomena, historical or legendary cataclysms, and known physical laws, we have before us a pleasantly written book with photographs, charts, diagrams, and far-reaching conjectures; a book calculated to attract both young and old, both learned and unlearned.

The author has collected legendary, conjectural, and argumentative matter as regards the destruction of that wonderful but possibly mythical continent of early civilisation, the much storied Atlantis, which, according to Plato, was the mother of both Athenian and Egyptian civilisation; so taking "Appian

Way " as our mental guide we can picture a great impact leading to the submerging of Atlantis and the break-off of the west from the east, a glance at a map of the world and at the interfitting of Eastern America to Western Europe and Africa assisting the mind at this stage.

We find nothing absurd, fantastic or even unreasonable in the book, but on the contrary much that is reasonable and suggestive ; still an opinion on the main issue would be premature.

It may, however, be allowable to suggest that the old argument for a fused interior loses much of its weight owing to the now known heating effects of radioactivity, and the remarkable essay of Babbage on the " Consequences of Central Heat " (see Babbage's Ninth Bridgewater Treatise, second edition, 1838, pp. 204-208) should be read once more and with care.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, NOVEMBER 2..Farmers' Club, at the Surveyors' Institution, 12, Great George Street, S.W. 4 p.m. Mr. J. R. Bond, " Soil Cultivation as a Factor in Crop Production."

Electrical Engineers, Institution of, (Local Centre), The University, Liverpool. 7 p.m. Address by the Chairman, Mr. A. E. Malpas.

University of London, King's College, Strand, W.C 5.30 p.m. Baron A. F. Meyendorff, " The Russian Church, Past and Present." (Lecture I).
5.30 p.m. Mr. C. J. Gadd, " The Science of Divination."
5.30 p.m. Mr. R. J. Bartlett, " Psychology and Advertising."

TUESDAY, NOVEMBER 3..Aeronautical Society and Institution of Automobile Engineers (Joint Meeting) at the Royal Society of Arts, John Street, Adelphi, W.C. 7 p.m. Wing Commander T. R. Cave-Browne-Cave, " The Evaporative Cooling of Aero Engines and Condensation of their Exhaust Gas."

Metals, Institute of (Local Sections), Chamber of Commerce, New Street, Birmingham. 7 p.m. Messrs. W. C. Gray and R. E. Ansell, " Some Notes on the Properties of Nickel-Silver."

At the Armstrong College, Newcastle-on-Tyne. 7.30 p.m. Dr. J. A. Smythe, " Methods and Uses of Metallography."

Electrical Engineers, Institution of (Western Centre), Chamber of Commerce, Swansea. 6 p.m. Chairman's Address by Mr. J. W. Burr.
(N. Western Centre), 17, Albert Square, Manchester, 7 p.m. Chairman's Address by Mr. A. G. Ellis.

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Address by Sir William Ellis, President.

University of London, University College, Gower Street, W.C. 5.30 p.m. Mr. P. Flemming, " Bloomsbury and the Bedford Estate—A Study in Street Names."
At King's College, Strand, W.C. 5.30 p.m. Miss Hilda D. Oakeley, " The Philosophy of Aristotle." (Lecture I).

WEDNESDAY, NOVEMBER 4..Heating and Ventilating Engineers, Institution of, Caxton Hall, Westminster, S.W. 7 p.m. Mr. J. J. Lassen, " The Modern Development of Combustion Recording."

Public Analysts, Society of, Burlington House, Piccadilly, W. 8 p.m.

Electrical Engineers, Institution of (Wireless Section), Savoy Place, Victoria Embankment, W.C. 6 p.m. Inaugural Address by Major B. Binyon.

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. P. Geyl, " Dutch Colonial Policy since 1816." (Lecture I).
5.30 Prof. W. M. Calder, " The Early Christian Inscriptions in Asia Minor." (Lecture I). Lectures II and III on Nov. 5 and 6.
At King's College, Strand, W.C. 5.30 p.m. Mons. P. Fort, " Trois Etoiles du Romantisme (Lamartine, Vigny, Musset).

THURSDAY, NOVEMBER 5..Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Chemical Society, Burlington House, Piccadilly, W. 8 p.m.

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. Mr. P. Dunsheath, " Dielectric Problems in High Voltage Cables."

Linnean Society, Burlington House, Piccadilly, W. 5 p.m.(1) Mr. M. Maxwell, " The Home of the Eastern Gorilla." (2) Miss E. Bolton, " Validity of Certain Species in *Neuropteris* Brongn." (3) Dr. H. S. Holden, and Mr. S. H. Clarke, " On the Seedling Structure of *Tilia europæa L.*"

Mechanical Engineers, Institution of (Local Centre), Glasgow. Mr. A. B. Smith, " Some Problems in the Applications of Lubricating Oils to Machinery."
Manchester, Mr. H. N. Gresley, " The Three Cylinder High Pressure Locomotive."

London County Council, Geffrye Museum, Kingsland Road, E. 7.30 p.m. Mr. P. A. Wells, " Figure and Colour in Furniture Design."

University of London, at the Royal Society of Medicine, Wimpole Sreet, W. 5 p.m. Dr. P. Watson-Williams, " The Toll of Chronic Nasal Focal Sepsis on Body and Mind." (Semon Lecture).
At King's College, Strand, W.C. 5.15. p.m. Prof. J. W. Allen, " The Social and Political Ideas of some Great Thinkers of the 16th and 17th Centuries." (Lecture III). ' Jean Bodin.'
5.30 p.m. Prof. Winifred Cullis, " The Influence of the Home in Social Hygiene."
At Bedford College for Women, Regent's Park N.W. 5.15 p.m. Mr. W. G. Constable, " English Mediaeval Painting."

FRIDAY, NOVEMBER 6..Mechanical Engineers, Institution of, Storey's Gate, S.W. 6 p.m. (Thomas Hawkesley Lecture). Sir John Aspinall, " Some Railway Notes Old and New."

University of London, University College, Gower Street, W.C. 8 p.m. Prof. G. Dawes Hicks, " Contemporary English Philosophy." (Lecture I).
At King's College, Strand, W.C. 5.30 p.m. Prof. J. S. Huxley, " Science and Culture." (Lecture I).

SATURDAY, NOVEMBER 7..London County Council, Horniman Museum, Forest Hill, S.E. 3.30 p.m. Mr. R. A. Smith, " Aspects of Roman London.' (Lecture I).

JOURNAL OF THE ROYAL SOCIETY OF ARTS

No. 3806 VOL. LXXIII.

FRIDAY, OCTOBER 30, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICE.

OPENING OF THE 172nd SESSION.

The Opening Meeting of the 172nd Session will be held on Wednesday, November 4th, when the Inaugural Address will be delivered by SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., LL.D., F.R.S., Chairman of the Council. The subject will be "The Organisation of Scientific Research throughout the Empire."

The chair will be taken at 8.30 p.m. Tea and coffee will be served in the Library after the meeting.

Other meetings of the Society will be held in accordance with the announcements printed in the Programme of Sessional Arrangements, copies of which have been posted to all Fellows of the Society.

ROYAL SOCIETY OF ARTS.

REPORT ON THE SOCIETY'S EXAMINATIONS, 1925.

INCREASE IN NUMBERS OF CANDIDATES.

The number of entries for the Society's examinations continues to rise in a satisfactory manner. The number of papers worked this year is 70,638, as compared with 67,282 in 1924, an increase of 3,356. The curve on page 1069 shows how the numbers have grown since 1900, when the figure was under 10,000.

The practical value of the certificates is coming to be more widely recognised every year. A great many of the largest business and industrial firms now directly encourage their employees to enter for the examinations, and grade their junior staffs according to the successes which they obtain.

CHANGES IN THE SYLLABUSES.

Certain changes are from time to time made in the syllabuses in order to keep the examinations thoroughly practical, up-to-date and suited to the requirements of the candidates. The most important changes in the syllabuses for 1926 are two:—

(1) After 1926, examinations in "Commercial Correspondence and Business Knowledge," will be discontinued. This subject has consisted mainly of two parts, the composition of a business letter, and questions dealing with office routine. The Council are of opinion that composition is best dealt with under the subject "English," while as for the other part, much of it is concerned with such points as postage rates, commercial terms and abbreviations, etc.,—points with which an intelligent junior clerk will very soon make himself familiar when he enters an office, and which are hardly worthy of a place in a serious examination.

On the other hand, the syllabus of the subject hitherto known as "Theory and Practice of Commerce," and in future to be styled "Commerce," has been revised, and will now be found to contain all that was really important in the syllabus of "Commercial Correspondence and Business Knowledge." If the new syllabus is followed, the Council are convinced that it will provide a better and sounder educational training than the old ones, and they hope that the changes will result in increased entries both for "English" and "Commerce."

(2). The pass mark for a second-class certificate in Stage II has been raised from 40 % to 50 %. This alteration brings the Intermediate Stage into line with the Advanced and Elementary Stages, in both of which 50% of the total marks is necessary to gain a certificate

SOME COMMON FAULTS IN CANDIDATES.

The reports of the examiners on the papers submitted to them are published each year in the pamphlets containing the various examination papers. In many of these may be found much useful criticism which it would well repay both teachers and students to study carefully. Unfortunately it would appear, from the way in which the same lessons have to be repeated year after year, that these reports are not read as attentively as they deserve, if they are read at all. There are several points which the examiners are always trying to emphasise, and of these the following three are the most constantly recurring:—

(1). A great many candidates fail because they will not, or cannot, read the questions intelligently. If a candidate is asked one question and he answers another, it either means that he does not know the answer to the question set, or worse still, that he is incapable of understanding the meaning of the words used. Teachers would do well to exercise their students frequently in working examination papers in order to ensure that this point is thoroughly drilled into them.

(2). Many candidates apparently think that any kind of handwriting is good enough for an examination answer. With the best will in the world even an examiner cannot read illegible writing, and if he has great difficulty in making out what a candidate has written he is naturally pre-disposed to punish the malefactor.

(3). Closely allied to the second point is the question of setting down the answers in a neat and methodical fashion. Some candidates even sprinkle different parts of one answer over several pages. An examiner who is put to the trouble of piecing together these random oddments is more than justified in deducting marks, for if he does not do this, how is he to make a just award to a candidate whose methods are excellent ?

What has been said on these three points is, of course, obvious, and it should be quite unnecessary to mention them ; but unfortunately the oft-repeated laments of the examiners show that it is not so.

REPORTS OF EXAMINERS.

The Examinations were held, as usual, at two periods, March-April and May. In March-April the number of entries was 26,071, and in May, 44,567. The papers worked were divided between the two Examinations as follows :—

	March-April.	May.	Total.
Advanced Stage	2,340	5,919	8,259
Intermediate Stage	8,180	17,247	25,427
Elementary Stage	15,551	21,401	36,952

In addition to the 70,638 papers worked in the written examinations, 677 candidates presented themselves for the *viva voce* Examinations in Modern Languages.

The subjects of Examination this year were :—

Arithmetic.
English.
Book-keeping.
Shorthand.
Typewriting.
Economic Geography.
Economic and Social History.
Economic Theory.
Theory and Practice of Commerce.
Railway Law and Practice.
Railway Economics.
Shipping Law and Practice.
Stock Exchange Law and Practice.
Insurance Law and Practice.
Advertising and Salesmanship.
French.

Précis-writing.
Commercial Correspondence and Business Knowledge.
Commercial Law.
Company Law.
Accounting.
Banking.
Costing.
Foreign Exchange.
German.
Italian.
Spanish.
Russian.
Danish and Norwegian.
Dutch.
Portuguese.
Swedish.

Arithmetic.—The total number of papers worked in all three stages was 7,728 as compared with 7,465 in 1924. In Stage III. the number of candidates was 260, of whom 26 obtained first-class certificates, 90 obtained second-class certificates, and 144 failed. The proportion of failures is a good deal higher than it ought to be, and is due to the fact that many of these candidates should have entered for Stage II instead of Stage III. The examiner again finds it necessary to draw attention to great weakness in the use of Logarithms.

In Stage II there were 1,867 candidates, of whom 356 obtained first-class certificates, 936 obtained second-class certificates, and 575 failed. A good many candidates had evidently not studied the syllabus, while some were quite unable to calculate correctly.

In Stage I, out of 5,601 candidates, 3,949 passed and 1,652 failed. It is satisfactory to note that the examiner again reports a general improvement in the standard of this stage, but again he has to draw attention to the lack of common sense on the part of some candidates. Thus, the thickness of sheet lead was often given as 118½ feet; 57.2 km. per hour was worked out as 60,750,600,000 feet per second; and the weight of one cubic foot of lead varied from 0.09 lb. to 9½ tons.

English.—It is satisfactory to notice that there is again a slight increase in the number of candidates taking this subject, the total being 5,973, as against 5,690 in 1924. Speaking generally, however, there is room for a great deal of improvement in the quality of the work submitted. In each stage there are a few excellent papers, but the proportion of these is far smaller than one would like to see; and there is a large percentage of work which is very poor indeed. Comparatively few candidates can put together a clear, relevant and logical essay, and unfortunately this weakness in English composition is commented on by almost all the examiners in the various subjects of examination. The teaching of composition appears to be one of the weakest spots in our whole educational system.

In Stage III there were 308 candidates, of whom 23 obtained first-class certificates, 159 obtained second-class certificates, and 126 failed. A few good essays were written, but there was far too much irrelevance, and the examiner writes: "one wearies of repeating the advice that candidates must think clearly about the subject and write clearly what they think." Some of the answers in the literary section ought to have been impossible for students at this stage: e.g., one stated that the Elizabethan Age was the Age of Anne and included Francis Thompson; another mentioned among the Elizabethans "Sir Thomas Moore, the writer of the famous Moore's Melodies"; whilst a third mentioned "Shakespeare, Byron, Shelley, Lamb and Coleridge."

In Stage II there were 1,855 candidates, of whom 127 obtained first-class certificates, 1,213 obtained second-class certificates, and 515 failed. Many candidates lost marks through not reading the questions carefully and so failing to realise what they were asked to do.

In Stage I there were 3,810 candidates, of whom 2,270 passed and 1,540 failed. The results of this examination, on the whole, show a slight improvement on those of last year. The examiner, however, quotes some extraordinary instances of illiteracy, and, he adds, "there was the usual crop of foolishness, *e.g.*, the eagle takes flight 'as soon as he hears the shrieks of the fish;' the fish-hawk rises from the sea 'with the fish between its teeth,' or 'with a helpless fish in its arms.'" The questions on the prescribed books were fairly well answered.

Book-keeping.—The preponderating popularity of this subject continues to increase, the total number of entries being 20,928 as compared with 20,409 in 1924. In Stage III there were 3,325 candidates, of whom 397 obtained first-class certificates, 1,408 obtained second-class certificates, and 1,520 failed. The leading papers were very good. Many candidates, however, were unable to submit practical rulings for a Stores Ledger or Time Sheet, and apparently it was generally expected that all examination exercises should result in a trading profit. Post-war conditions might have rendered them familiar with the contrary position.

In Stage II there were 7,716 candidates, of whom 812 obtained first-class certificates, 4,925 obtained second-class certificates, and 1,979 failed. Here the examiner reports that a number of candidates failed from not reading the question paper with sufficient care, while too many answers show indications of "parrot learning."

In Stage I there were 9,887 candidates, of whom 5,717 passed and 4,170 failed. Here, too, marks were in many cases lost through careless reading of the questions, while the arithmetic was often weak.

Economic Geography.—In Stage III there were 65 candidates, of whom 3 obtained first-class certificates, 42 obtained second-class certificates, and 20 failed. The examiner again complains of the quality of the map-work, which is in many cases inferior to that in the elementary stage. A good many candidates have also misread some of the questions.

In Stage II there were 236 candidates, as against 158 last year. Of these

13 obtained first-class certificates, 159 obtained second-class certificates, and 64 failed. The quality of the papers worked in this stage shows a distinct improvement over that of last year.

In Stage I there were 325 candidates, of whom 241 passed and 84 failed. On the whole the general improvement in the standard of the work reported last year is well maintained, some of the map-work being quite admirable. Certain features of the work indicated that in some centres the teaching is still very unscientific. " If teachers could only be persuaded to *try* teaching scientifically," writes the examiner, " they would be amazed at the saving of their own time and trouble, and the increased success of their pupils."

Shorthand.—There has been a large increase in the number of candidates taking this subject, the total being 14,691, as against 13,518 in 1924—a rise of 1,173. In Stage III there were 1,237 candidates ; 132 passed at 140 words per minute, 414 at 120 words per minute, and 691 failed. These results show a marked improvement as compared with those of 1924. In Stage II of 6,629 candidates 881 passed at 100 words per minute, 2,707 passed at 80 words per minute, and 3,041 failed. In Stage I of 6,825 candidates, 2,600 passed at 60 words per minute, 2,172 passed at 50 words per minute, and 2,053 failed. The general standard of work was good.

Typewriting.—The present examiner has now examined in typewriting for twenty-five years, and he takes the occasion to write his impressions of the changes which have taken place in that period. In 1901 the number of candidates was 1,223 ; this year it is 7,174, a figure " which very forcibly illustrates the increased recognition of typewriting as an educational subject and the general adoption of the typewriter in office equipment during the last quarter of a century." A comparison of the work done in 1901 with that of to-day shows a distinct improvement in manipulation, and candidates are less anxious than they were to acquire speed at the expense of accuracy. Unfortunately, however, " there has been a deterioration during the last few years in spelling and punctuation," and it would appear that the greater facilities now offered have encouraged too many young people to take up typewriting as a livelihood, for which they are educationally unfitted.

In Stage III there were 654 candidates, 144 of whom obtained first-class certificates, 386 obtained second-class certificates, and 124 failed. The standard here was very satisfactory, and there was a marked improvement in accuracy, quality of touch, and speed. In Stage II there were 2,580 candidates, of whom 550 obtained first-class certificates, 1,487 obtained second-class certificates, and 543 failed. Here, too, the standard was good, although the spelling was bad in many cases.

In Stage I there were 3,940 candidates, of whom 3,152 passed and 788 failed. The manipulation of the typewriter was generally good, but bad spelling was far too prominent. The commonest shipping and counting-house abbreviations appeared to be unknown to many candidates ; thus, " f.o.b.' was rendered as " found on back," " free of observation," " front or back," " for ordinary business," " for old bachelors," and " following on behind."

Economic and Social History.—It is to be regretted that there has been a falling off in the number of candidates taking this subject, the total being 83, as compared with 146 last year, although the figure is better than that for 1923, viz. 48. In Stage III there were 16 candidates. Only one failed, but on the other hand only one obtained a first-class certificate. The papers generally reached a creditable standard. In Stage II there were 39 candidates, of whom 4 obtained first-class certificates, 25 obtained second-class certificates, and 10 failed, There were a few papers of outstanding excellence, but the work as a whole was disappointing. In Stage I there were only 28 candidates (as against 85 last year), of whom 20 passed and 8 failed. None of the work submitted reached a very high standard, but the general level was satisfactory.

Economic Theory.—The total number of entries in this subject was 453 as compared with 378 in 1924. In Stage III there were 172 candidates, of whom 12 obtained first-class certificates, 109 obtained second-class certificates, and 51 failed. Although several candidates entered for this stage who would have been better advised to attempt Stage II, a great many papers were of excellent quality and some of distinctly high achievement. In Stage II there were 281 candidates, of whom 19 obtained first-class certificates, 204 obtained second-class certificates, and 58 failed. The general level reached by the majority of these papers was satisfactory ; but the examiner finds it necessary to remind candidates that they should read the questions carefully before attempting to answer them.

Précis-Writing.—The number of candidates entering for this subject was never very large, and last year it had dropped to 101. There is a slight recovery this year, however, the total being 130. In Stage III there were 60 candidates, of whom 6 obtained first-class certificates, 40 obtained second-class certificates, and 14 failed. In Stage II there were 70 candidates, of whom 12 obtained first-class certificates, 46 obtained second-class certificates, and 12 failed. The improvement shown in the standard of work last year has been more than maintained in this stage.

Commercial Correspondence and Business Knowledge.—The total number of entries in this subject was 3,968. In Stage III there were 109 candidates, of whom 7 obtained first-class certificates, 38 obtained second-class certificates, and 64 failed. In Stage II there were 1,023 candidates, of whom 71 obtained first-class certificates, 783 obtained second-class certificates, and 169 failed. In Stage I of 2,836 candidates, 1,877 passed and 959 failed.

The reasons for discontinuing the examinations in this subject after 1926 are given on page 1057.

Commercial Law.—489 candidates entered in this subject, an increase of 56 as compared with last year's total. In Stage III there were 168 of whom 39 obtained first-class certificates, 105 obtained second-class certificates, and 24 failed. There were fewer very good papers than in 1924, but a good many more of fair merit, and the proportion of failures was decidedly smaller. In Stage II there were 321 candidates, of whom 122 obtained first-class certificates, 183 obtained second-class certificates and only 16 failed. The examiner has to complain that the writing was often almost illegible, and the spelling was much worse than one should expect in an examination of this kind.

Company Law.—The total number of entries in this subject was 308, exactly the same number as last year. In Stage III there were 133 candidates, of whom 39 obtained first-class certificates, 105 obtained second-class certificates, and 24 failed. A large majority of the candidates had evidently received careful instruction of a sound, practical nature such as will be of use in actual company work. It is somewhat curious that although the examiner has in the last two years informed the candidates that the Royal Society of Arts is not a limited company, more than half the advanced students stated " that it is a private guarantee company which has not issued a prospectus inviting the public to subscribe for shares; and has had a licence to dispense with the word ' limited.' " In Stage II there were 175 candidates, of whom 95 obtained first-class certificates, 75 obtained second-class certificates and only 5 failed. The high proportion of first-classes and the very small proportion of failures speak strongly for the general excellence of the work submitted in this stage.

Costing.—This subject was introduced into the examination syllabus for the first time this year, when 100 candidates entered. Only 1 obtained a first-class certificate, 30 obtained second-class certificates, and 69—a very large proportion—failed. Most candidates were deficient in the power of expressing their ideas, and their definitions of direct and indirect labour and material were very vague.

Accounting.—The number of candidates in this subject was 570, of whom 56 obtained first-class certificates, 253 obtained second-class certificates, and 261 failed. The work submitted was of average merit, but too many candidates did their work in a slipshod manner, portions of their answers being scattered throughout the paper.

Banking.—Only 26 candidates entered for this subject, of whom 4 obtained first-class certificates, 11 obtained second-class certificates, and 11 failed.

Foreign Exchange.—In this subject, there were 38 entries in all as compared with 25 last year, when the subject was introduced into the syllabus. In Stage III there were 12 candidates, of whom 2 obtained first-class certificates, 5 obtained second-class certificates and 5 failed. In Stage II, of 26 candidates 3 obtained first-class certificates, 18 obtained second-class certificates, and 5 failed. The examiner's report shows the special points in which the answers were weak.

Theory and Practice of Commerce.—There is a healthy increase in the number of entries in this subject, last year's total of 1,040 having grown to 1,223. This is particularly satisfactory in view of the importance attached by the Council to this study, an importance which has led them to substitute "Commerce" in and after 1927 for " Commercial Correspondence and Business Knowledge," as has been mentioned above. In Stage III there were 203 candidates, of whom 9 obtained first-class certificates, 106 obtained second-class certificates, and 88 failed. The proportion of first-class candidates is disappointing and many of the students do not seem to have had sufficient practice in expressing their thoughts on paper.

In Stage II of 503 candidates, 60 obtained first-class certificates, 387 obtained second-class certificates, and 56 failed. In the May examination the percentage of failures was exceedingly low, being only 6.45—a very satisfactory feature. In Stage I there were 517 candidates, of whom 283 passed and 234 failed. Nearly all the candidates require further drilling in the proper basing and calculation of percentages, and a very common fault was failure to read the exact terms of the questions.

Railway Law and Practice.—The examiner reports that the improvement in the quality of the work submitted in this subject, to which he drew attention last year, is continued, but unfortunately the number of entries continues to fall, being 49 as against 58 in 1924. Of these, 8 obtained first-class certificates 31 obtained second-class certificates and 10 failed. The general standard reached by the candidates is " distinctly satisfactory," and it is pleasant to note that the examiner reports " a great advance in the English and a total absence of the bad spelling which used to mar some otherwise good papers."

Railway Economics.—25 candidates entered this subject; of whom 4 obtained first-class certificates, 15 obtained second-class certificates, and 6 failed. Here again, the examiner notes " a very marked improvement in the English of the candidates. The chief defect in the work is traceable to the students' knowledge of the subject not being up-to-date. Candidates require to realise that, when dealing with railways, they cannot afford to be half-a-dozen years behind the times."

Stock Exchange Law and Practice.—In this subject there were only 33 candidates as compared with 45 last year, when the examination was held for the first time. In Stage III there were 11 candidates, of whom 8 obtained first-class certificates, 1 obtained a second-class certificate, and 2 failed. In Stage II 5 obtained first-class certificates, 13 obtained second-class certificates and 4 failed. The high proportion of first-classes in Stage III is very unusual and satisfactory.

Insurance Law and Practice.—Of the 9 candidates in this subject, 3 obtained first-class certificates, 4 obtained second-class certificates, and 2 failed. The general style of the papers, including handwriting and literary merit, was satisfactory, but the number of entries was exceedingly small, and showed a falling off as compared with last year, when the figure was 19.

Advertising and Salesmanship.—In view of the demand for capable advertising men and of the high salaries obtainable in this profession, it was expected that the number of entries would show a substantial increase as compared with the 1924 total, instead of which the figure has fallen from 41 to 35. Of these 9 obtained first-class certificates, 19 obtained second-class certificates, and 7 failed. A few candidates did really excellent work, and the examiner thinks that in a field where the demand for competent men and women is much greater than the supply the success of these is assured.

MODERN LANGUAGES.

French.—It is very seldom that one comes across a report which speaks of the work of candidates in terms so enthusiastic as those used by the examiner in Stages III and II in French. The work of all the first-class candidates and of at least one-third of the second-class candidates in Stage III, would, he writes, be considered creditable in any University Honours Examination. In many cases the French was faultlesss both in the translation from English and in the free composition. The results of the examination are evidence that there is remarkably good teaching of French in many centres and that real and enlightened interest is taken in this country in all that concerns French language and literature.

For the last four years a special prize of £5 has been offered by M. Stéphane Barlet, formerly Examiner in French for the Society, to the candidate writing the best free composition in French in Stage III. This was won this year by Mr. Arthur Geoffrey Bayliss, a London External Student, who presented an admirable French essay.

There were, in all, 4,786 entries in French. In Stage III, of 492 candidates, 62 obtained first-class certificates, 267 obtained second-class certificates, and 163 failed. In Stage II there were 1,675 candidates, of whom 241 obtained first-class certificates, 1,051 obtained second-class certificates, and 383 failed. Here, too, the examiner finds the standard exceedingly high, one candidate actually obtaining full marks—a very rare occurrence in a language paper. As in 1924, the examiner has again prepared a very full report on the work done in Stages II and III which should prove exceedingly helpful to serious students of French.

In Stage I there were 2,619 candidates, of whom 2,106 passed and 513 failed. A good many would have done considerably better had they read the questions carefully and understood what they meant.

German.—It is interesting to note that there is a considerable increase in the number of candidates in German; the total this year being 429, as compared with 335 in 1924. In Stage III of 60 candidates 22 obtained first-class certificates, 20 obtained second-class certificates, and 18 failed. The report on these candidates is very satisfactory. The papers showed abundant evidence of careful and intelligent study; several candidates showed considerable knowledge of German literature and history, and might have sat with confidence for a University examination.

In Stage II of 160 candidates 23 obtained first-class certificates, 89 obtained second-class certificates, and 48 failed. The work here was not so good as in Stage III. The translation into English was below the average, and there were too many bad grammatical blunders.

In Stage I of 209 candidates 137 passed and 72 failed. Although the standard in this stage is still low, the improvement that was noted last year is maintained; but too many papers show gross carelessness and ignorance of German grammar.

Italian.—In Stage III there were 18 candidates; 8 obtained first-class certificates, 7 obtained second-class certificates, and 3 failed. The best showed that they had been very carefully prepared and that their reading had been extensive. In Stage II of 34 candidates, 9 obtained first-class certificates, 20 obtained second-class certificates, and 5 failed. In Stage I there were 41 entries; 32 candidates passed and 9 failed. The failures were almost entirely due to lack of grammatical knowledge.

Spanish.—This subject continues to stand second in popularity among modern languages, the total number of entries being 590. In Stage III there were 93 candidates, of whom 18 obtained first-class certificates, 55 obtained second-class certificates, and 20 failed. The examiner reports a distinct all round improvement in the papers as compared with previous years, one candidate showing a knowledge of the language much superior to anything previously met with in this examination. In Stage II, of 190 candidates 41 obtained first-class certificates, 128 obtained second-class certificates, and 21 failed.

The general standard here is good, but students are urged to read more widely in order to enlarge their vocabularies. In Stage I, of 307 candidates 244 passed and 63 failed. The papers in this stage were specially well done this year, and the examiner reports that some of the candidates might well have entered for a higher stage. As a rule examiners find that students would have done better to attempt a lower stage than they have chosen.

Russian.—The popularity enjoyed by this subject just before the Revolution in Russia shows no sign of returning. This year there were only 18 entries in all. In Stage III of 4 candidates one obtained a first-class certificate and the other 3 obtained second-class certificates. In Stage II there were 7 candidates of whom 2 obtained first-class certificates, 4 obtained second-class certificates, and 1 failed. In Stage I there were also 7 candidates, of whom 6 passed and 1 failed. The standard reached here was considerably higher than usual.

Danish and Norwegian.—Five candidates entered for this subject in Stage II, of whom 3 obtained first-class certificates and 2 obtained second-class certificates.

Portuguese.—There were 13 candidates in all in Portuguese. In Stage III, of 6 candidates one obtained a first-class certificate, and 5 obtained second-class certificates. In Stage II of 7 candidates, 1 obtained a first-class certificate, and 6 obtained second-class certificates.

Swedish.—In Swedish, 6 candidates entered in Stage II, and of these 2 obtained first-class certificates, 1 obtained a second-class certificate, and 3 failed.

ORAL EXAMINATIONS.

The results of the Oral Test which is now compulsory for all Candidates in the Advanced Stage of French, German, Spanish, and Italian were well above the average; although there were 118 fewer candidates than in 1924, there were 41 more passes with distinction this year. An important part of the Oral Test is the taking down of a passage dictated in the foreign language by the examiner, and in the past this has been a source of great weakness with many candidates. It is gratifying to be able to state that the examiners now report a very great improvement in this branch of the examination.

GROUP CERTIFICATES IN COMMERCIAL SUBJECTS.

The increase, noted in last year's report in the number of Candidates entered from Higher Elementary Schools, and also the new Central Day Schools set up under various Education Authorities, has been well maintained. Most of

ORAL EXAMINATIONS HELD DURING 1925.

Subject.	No. of Examination Centres.	No. of Examiners.	No. of Candidates examined	Passed with Distinction.	Passed.	Failed.
French ..	50	35	517	137	277	103
German ..	6	5	57	9	33	15
Spanish ..	14	12	86	29	46	11
Italian ..	3	3	17	7	8	2
	73	55	677	182	364	131

these Candidates take a number of subjects qualifying for the Group Certificate in Elementary Commercial Subjects. To gain this special Certificate Candidates must pass in Arithmetic, English and two other subjects within three consecutive years, but it is satisfactory to find that many pupils from Day Schools pass in the necessary subjects in one year. In view of the fact that a fairly high standard is maintained in the Elementary Stage (it is by no means a first year's examination) the results at these Schools give evidence of really excellent preparation.

In order to encourage students to take up groups of subjects, the Council decided in 1924 to offer £200 in prizes for candidates who completed group certificates in Commercial Subjects in the Advanced and Intermediate Stages in 1925.

Fourteen prizes of £10 each were offered in the Advanced Stage and twelve prizes of £5 each in the Intermediate Stage.

The qualification for Group Certificates is as follows :—

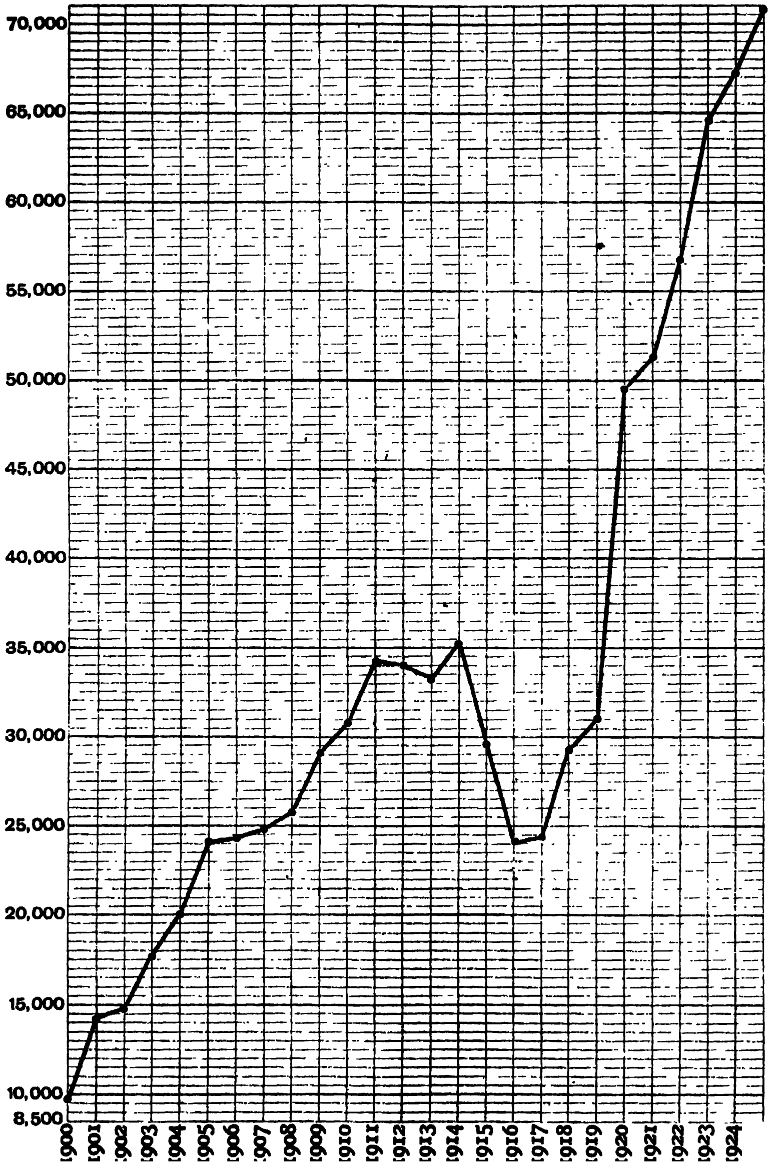
ADVANCED STAGE.

Candidates must pass in the following four subjects in the Advanced Stage in three consecutive years : Economic Theory, Theory and Practice of Commerce (or Commerce), Book-keeping, and any one of the remaining subjects (other than Shorthand, Typewriting, Précis-Writing, and Commercial Correspondence and Business Knowledge) in which an Examination in the Advanced Stage is held.

INTERMEDIATE STAGE.

Candidates must pass in the following four subjects either in the Advanced or Intermediate Stage in three consecutive years : Theory and Practice of Commerce (or Commerce), Arithmetic, Book-keeping and any one of the other subjects in which an Examination in the Intermediate Stage is held. (For the purpose of this Certificate Shorthand and Typewriting will be considered as one subject).

DIAGRAM SHOWING NUMBERS OF PAPERS WORKED IN THE EXAMINATIONS, 1900-1925.



DETAILS OF THE 1925 EXAMINATIONS.

SUBJECTS.	STAGE III.—ADVANCED.				STAGE II.—INTERMEDIATE.				STAGE I.—ELEMENTARY.			Total number of Papers worked in all Stages.	
	Papers worked.	1st-class Certificates.	2nd-class Certificates.	Not passed.	Papers worked.	1st-class Certificates.	2nd-class Certificates.	Not passed.	Papers worked.	Passed.	Not passed.	1925	1924
Arithmetic	260	26	90	144	1,867	356	936	575	5,601	3,949	1,652	7,728	7,465
English	308	23	159	126	1,855	127	1,213	515	3,810	2,270	1,540	5,973	5,690
Book-keeping	3,325	397	1,408	1,520	7,716	812	4,925	1,979	9,887	5,717	4,170	20,928	20,409
Economic Geography	65	3	42	20	236	13	159	64	325	241	84	626	499
Shorthand	1,237	132	414	691	6,629	881	2,707	3,041	6,825	4,772	2,053	14,691	13,518
Typewriting	654	144	386	124	2,580	550	1,487	543	3,940	3,152	788	7,174	6,476
Economic and Social History ..	16	1	14	1	39	4	25	10	28	20	8	83	146
Economic Theory	172	12	109	51	281	19	204	58	—	—	—	453	378
Précis-writing	60	6	40	14	70	12	46	12	—	—	—	130	101
Commercial Correspondence and Business Knowledge ..	109	7	38	64	1,023	71	783	169	2,836	1,877	959	3,968	3,996
Commercial Law	168	39	105	24	321	122	183	16	—	—	—	489	433
Company Law	133	24	80	29	175	95	75	5	—	—	—	308	308
Accounting	570	56	253	261	—	—	—	—	—	—	—	570	623
Banking	26	4	11	11	—	—	—	—	—	—	—	26	31
Costing	100	1	30	69	—	—	—	—	—	—	—	100	—
Foreign Exchange	12	2	5	5	26	3	18	5	—	—	—	38	25
Theory and Practice of Commerce	203	9	106	88	503	60	387	56	517	283	234	1,223	1,040
Railway Law and Practice	49	8	31	10	—	—	—	—	—	—	—	49	58
Railway Economics	25	4	15	6	—	—	—	—	—	—	—	25	29
Shipping Law and Practice	39	8	23	8	—	—	—	—	—	—	—	39	33
Stock Exchange Law & Practice	11	8	1	2	22	5	13	4	—	—	—	33	45
Insurance Law and Practice	9	3	4	2	—	—	—	—	—	—	—	9	19
Advertising and Salesmanship	35	9	19	7	—	—	—	—	—	—	—	35	41
French	492	62	267	163	1,675	241	1,051	383	2,619	2,106	513	4,786	4,808
German	60	22	20	18	160	23	89	48	209	137	72	429	335
Italian	18	8	7	3	34	9	20	5	41	32	9	93	98
Spanish	93	18	55	20	190	41	128	21	307	244	63	590	638
Russian	4	1	3	—	7	2	4	1	7	6	1	18	22
Danish and Norwegian ..	—	—	—	—	5	3	2	—	—	—	—	5	10
Dutch	—	—	—	—	—	—	—	—	—	—	—	—	4
Portuguese	6	1	5	—	7	1	6	—	—	—	—	13	—
Swedish	—	—	—	—	6	2	1	3	—	—	—	6	4
Totals, 1925	8,259	1,038	3,740	3,481	25,427	3,452	14,462	7,513	36,952	24,806	12,146	70,638	—
„ 1924	8,414	1,032	3,561	3,821	23,772	3,869	13,056	6,847	35,096	23,469	11,627	—	67,282

On October 21st, the last day for receiving applications for the above prizes, 21 applications had been received for Advanced, and 79 applications for Intermediate certificates, and it is hoped to publish the names of the prize winners for 1925 in the course of a few weeks.

The thanks of the Council are once more accorded to the Court of the Clothworkers' Company, who have generously renewed their grant of £40, towards providing medals in all the subjects of examination where the work of candidates attains a sufficiently high standard. There is no doubt that there is very keen competition for these medals, and that they have done much to maintain or raise the level of excellence in the papers worked.

The Examination Syllabus for 1926* has been issued. In it will be found the fullest possible information about the examinations, a syllabus of each stage of each subject, and list of centres. The papers set in 1925 have been reprinted in six pamphlets. Each pamphlet contains, in addition to the papers of each stage, the syllabuses of the subjects in the pamphlet and the Examiners' reports on the papers worked.

The regulations for the Oral Examinations in Modern Languages are also given at full length in the syllabus.

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* The price of the Syllabus for 1926 is 4*d*., post free. Copies can be obtained on application to the Examinations Officer, Royal Society of Arts, Adelphi, London, W.C.(2). The price of the pamphlets containing the 1925 papers is 4*d*. each, post free. Particulars of these may be obtained as above.

OBITUARY.

JOHN EDWIN RHODES, A.M., M.D.—The death took place on September 2nd of Dr. John Edwin Rhodes, who was elected a Fellow of the Royal Society of Arts in 1920. He was well known in Chicago as a physician and surgeon, specialising in diseases of the throat, and for many years he held a chair in the Rush Medical College, Chicago.

JAMES SYKES GAMBLE, C.I.E., M.A., F.R.S.—Mr. James Sykes Gamble died at his residence in East Liss, Hampshire, on October 16th, at the age of 78. Born in London in 1847, he was educated at the Royal Navy School at New Cross, and at Magdalen College, Oxford, where he held a demyship. After graduating with first-class honours in the Final School of Mathematics, he was selected for the Indian Forest Service, and underwent his course of practical training at the Ecole Nationale des Eaux et Forêts at Nancy. He went out to India in 1871, and served in British Burma and Bengal. In 1882 he was transferred to the Madras Presidency, and subsequently to the United Provinces, where he was Director of the Imperial Forest School at Dehra Dun and *ex officio* Conservator of the "School Circle."

Mr. Gamble was the author of several works of great botanical importance. In 1887 he published his "List of Trees, Shrubs and Climbers of the Darjeeling District, Bengal," of which a second edition appeared in 1895. In 1881 appeared his well-known "Manual of Indian Timbers," which was republished with amplifications in 1902, and reached a third edition three years ago. He also wrote a "Flora of the Madras Presidency," "The Bambuseæ of British India," and (with the late Sir George King) "Materials for the Flora of the Malay Peninsula."

He retired from the Indian Forest Service in 1899, and in that year he received the C.I.E., and was elected an F.R.S. He was awarded the Jury Medal and Diploma of the Paris Exposition of 1900 for his services in organising the forestry section of the Indian Court, and the Barclay Medal of the Royal Asiatic Society of Bengal. He was appointed Lecturer on Indian Forest Botany in the University of Oxford, and played an important part in the selection and training of forest officers.

He joined the Royal Society of Arts in 1899, and occasionally took part in discussions at the Society's meetings.

NOTES ON BOOKS.

BUNGALOWS AND SMALL COUNTRY HOUSES. Edited and published by "The Architect," Ludgate Circus, E.C. 2*s*. 6*d*. net.

The extraordinary popularity of the motor car has, among other things, done much to change the face of the country, especially in the neighbourhood of the large towns. Take a run along the great North Road, and for twenty or thirty miles you will see endless little houses, many of them with garages nearly as big as themselves. Nor are these building operations limited to the main arteries of traffic; the countryside between them is sprouting with mushroom growths, and the estate agent is flourishing exceedingly. Amongst all this development how often does one see a house or cottage that has any attractions ? Most of them are simply deplorable, and make the environs of a place like London a veritable eyesore.

The tragic thing about it, too, is that there is no necessity for all this ugliness. If people who contemplate building themselves a little house in the country would consult this book they would find a wealth of pleasant suggestions. We have plans and elevations of numerous bungalows and small houses by well-known architects. Some of these, notably a Tudor cottage by Mr. Harold E. Moss, A.R.I.B.A., a bungalow at Camberley by Mr. C. Wontner Smith, F.R.I.B.A., and a house at Coombe Hill by Messrs. H. F. Murrell and R. M. Piggott, A.A.R.I.B.A., are quite delightful. Particulars are also given showing the accommodation provided, and the prices, which are no higher than those charged for the monstrosities which have become so painfully common.

CORK, SILK, TOBACCO AND OLIVE OIL INDUSTRIES IN SPAIN.

The report on the industries and commerce of Spain by the Commercial Secretary to H.M. Embassy in Madrid, gives details regarding cork, silk, tobacco and olive oil industries of the country, from which the following is taken :—

CORK.—The annual output of cork bark is estimated at between 60 and 70,000 tons, of a value of 16 millions of pesetas. The cork industry is one of the oldest in the country, having been established in the province of Gerona in the beginning of the 19th century. In recent years modern factories have been set up in the neighbouring province of Barcelona, and although the introduction of the Crown cork adversely affected the true bottle cork industry, during last year there was a revival in the manufacture of certain kinds of corks, especially those for the bottling of sparkling wines. For the manufacture of these corks only the best quality cork bark is used; consequently there is a considerable demand for this quality, and prices have remained high. Poor qualities and waste, which are used for the manufacture of linoleum and the preparation of cork boards for insulation purposes, only fetch a nominal price. Exports of the manufactured boards to England, Belgium, and the United States of America have increased considerably. The linoleum factory in Madrid should now be an important consumer of waste cork which hitherto has principally been exported.

SILK.—The cultivation of the silkworm on the Mediterranean coast, especially in the province of Murcia, is an important industry. The average number of cocoons harvested yearly during the last 10 years was 926,100, giving an average normal production of crude silk of 73,200 kilos. Silkworm eggs are distributed gratis by the Government through their sero-cultural stations, and peasants are encouraged to take eggs to these stations for examination. At the Murcia station a refrigerating chamber has been set up, where the farmers and peasants can leave eggs to hibernate. The cocoons are usually sold direct to the Spanish spinners established in Murcia, Valencia, Barcelona, and Seville, although some growers sell them to the French spinners at Lyons.

TOBACCO.—It must be concluded that the scheme for the encouragement of tobacco cultivation in Spain, which was initiated in 1917, did not at first receive the support of cultivators, as in 1921 there were only 17 growers. This number has now increased to 1,050 in 1924, while the area under cultivation has risen from 116 hectares in 1921, to 1,000 hectares in 1924. In March, 1925, a central commission was appointed to study the question further, and to make a report on the result of the experiments carried out to date.

OLIVE OIL.—During November, 1924, an olive oil conference, at which only national growers and producers were represented, was held in Madrid. This Conference, which was under the auspices of the Council of National Economy, was opened by H.M. the King of Spain, the subsequent proceedings being presided over by the Vice-President of the Council.

The assembly submitted their conclusions to the Government and the following recommendations are extracted from their report:—

(1) The creation of a general association of olive-growers.
(2) The use of tank wagons to facilitate distribution in the country.
(3) Facilities to importers of tinplate and the extension to two years of the permission to export the manufactured containers, and modifications in the existing regulations regarding the proof of re-exportation, in the sense that this should devolve on the authorities at home, and not on the consuls at the port of arrival.
(4) That the Superior Banking Council should be requested to investigate the possibilities of establishing an Export Bank to give export credit facilities.
(5) That the export tax on oil should be suppressed.

Effect has already been given to headings 3 and 5, the recommendation under heading 3 being of considerable importance to the British tinplate trade.

The Madrid Conference was no doubt a preliminary to the Seventh International Congress which was held in December at Seville. The congress was attended by some 1,500 members, including representatives of France, Italy, and Portugal; an exhibition of machinery and implements peculiar to the olive industry was held at the same time. The selection of Seville was certainly fortunate, in that Andalusia produces two-thirds of Spain's output of an average of 300,000 tons per annum, which is more than 45 per cent. of the world's production. December is the height of the olive harvest, and members of the Congress had an opportunity of studying on the spot the various methods adopted in gathering the crop and extracting the oil. The Congress did not confine itself to studying the means of production or marketing the olive and its products, but extended its attention to every possible question affecting the industry, diseases of the tree and other pests being carefully considered. The need of adequate protection against disease is of great importance to Spain, as some districts are infested with the olive fly, and the quality of oil obtained from infected olives is largely impaired.

THE GROUND-NUT OR MONKEY-NUT.

The ground-nut or "monkey-nut" as it is commonly called, is cultivated in almost all the warmer countries of the world, especially India, China, West Africa and the United States, and apart from the huge quantities that are consumed in these countries, no less than 800,000 tons are exported to Europe alone. The nuts are largely eaten either in the raw state or roasted, but by far the greater quantity are used as a source of oil. For a great many years Marseilles has been the chief centre in Europe for the production of ground-nut oil, but considerable quantities are now prepared in Great Britain, where the industry was started during the war. China also produces a very large quantity of the oil. Ground-nut oil is used for a variety of purposes. It is largely employed as a salad oil in place of olive oil, and in the manufacture of margarine and other edible fats. It also finds a use as an illuminant and lubricant, whilst the lower qualities are employed for soap-making. The cake left after the oil has been expressed from the nuts forms a valuable feeding-stuff for cattle and other farm animals.

The "Bulletin of the Imperial Institute" contains a detailed article on the cultivation and utilisation of the ground-nut. It gives particulars of value to the producer regarding methods of growing the plant and harvesting and marketing the crop, as well as information on the preparation and uses of the oil. An interesting account is given of the position of ground-nut cultivation within the British Empire. This shows that in addition to India, Gambia and Nigeria, where the crop is already largely grown for export, many other parts of the Empire are suitable for its production on a large scale. The present contributions from the latter, however, are relatively small, although Tanganyika, the Sudan, and Kenya show a steady increase in exports in recent years.

CONCRETE RAILWAY WAGONS.

Iron and wood floors in railway wagons may be replaced by cement, if experiments recently conducted in Germany continue to prove successful. According to a report by the United Stated Consul-General at Frankfort on Main, a composition called "Eisenbeton" has been used in the construction of the floors of railway goods wagons with a great measure of success. The first wagon made of this substance was built in 1919 at Heidelberg, and was tested in the railway goods yards. The wagon withstood concussion at a speed of 27 kilometres, and shifting tests were so satisfactory that after five years of service this test wagon still remains in perfect condition.

The new type of wagon weighs 20 tons, and in appearance is much the same as an ordinary iron one. The cost of manufacture, however, is much less than for iron, and although the concrete car is much heavier, the fact that the danger of rust is eliminated offsets this disadvantage. The wagon with concrete floor requires so little repair work in comparison with wood and iron wagons that the railway administration is favourably impressed, since the yearly expenditure for repairs on the old type of wagon reaches a considerable amount.

A company for the manufacture of these wagons has been formed at Darmstadt.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

Monday, November 9..Mechanical Engineers, Institution of, Storey's Gate, S.W. 6 p.m. (Graduates' Section.) Mr. E. B. Ball, "Some Engineering Features in connection with Irrigation in South Africa."

Electrical Engineers, Institution of (Informal Meeting). Savoy Place, Victoria Embankment, W.C. 7 p.m. Discussion on "Modern Developments of Telephone Cables."
(N. Eastern Section.) At Armstrong College, Newcastle-on-Tyne. 7 p.m. Mr. P. Dunsheath, "Dielectric Problems in High Voltage Cables."

Surveyors' Institution, 12, Great George Street, S.W. 8 p.m.

Geographical Society, 131, New Bond Street, W. 8.30 p.m.

Metals, Institution of (Scottish Local Centre), 39, Elmbank Crescent, Glasgow. 7.30 p.m. Dr. J. A. Cranston, "The Binding Forces between Atoms."

University of London, at King's College, Strand, W.C. 5.30 p.m. (Swiney Lectures.) Dr. W. T. Gordon, "Geology and Civilization." (Lecture I.)
6 p.m. Mr. H. W. Steed, "Central Europe and the War." (Lecture I.)
5.30 p.m. Baron A. F. Meyendorff, "The Russian Church, Past and Present." (Lecture II.)
At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Dr. O. Vocadlo, "From Bohemia to Czechoslovakia." (Lecture I.)
At the Birkbeck College, Fetter Lane, E.C. 8.15 p.m. Lord Eustace Percy. 102nd Anniversary Foundation Oration.

Tuesday, November 10..Aeronautical Engineers', Institution of, at the Junior Institution of Engineers, 39, Victoria Street, S.W. 6.30 p.m. Mr. M. L. Bramson, "Practical Flying."

Electrical Engineers', Institution of (N. Midland Centre), Hotel Metropole, King Street, Leeds. 7 p.m. Mr. S. Derwen Jones, Chairman's Address.
(Scottish Centre), Royal Technical College, Glasgow. 7.30 p.m. Prof. M. Maclean, Chairman's Address.

Marine Engineers, Institution of, 85, The Minories, E. 6.30 p.m. Mr. E. F. Spanner, "A Proposed Method of Minimising risks due to Collision in the Construction of Ships."

Transport, Institute of (Midland Graduate Society), at the Imperial Hotel, Birmingham. 6.30 p.m. Mr. A. Jackson, "Passenger Fare Charges on Urban Tramway Services."

University of London, University College, Gower Street, W.C. 5.30 p.m. Lieut.-Col. E. F. Strange, "Far Eastern Art—I., Chinese and Japanese Painting."
At King's College, Strand, W.C. 5.30 p.m. Miss H. Oakeley, "The Philosophy of Aristotle." (Lecture II.)
5.30 p.m. Sir Bernard Pares, "The History of Russia before Peter the Great." (Lecture V.)

Wednesday, November 11..Civil Engineers, Institution of, Great George Street, S.W. (Informal Meeting.) 6 p.m. Sir E. Owen Williams, "The Relative Economy of Different Classes of Reinforced Concrete Work."

Electrical Engineers, Institution of, (South Midland Centre), at the University, Edmund Street, Birmingham. 7 p.m. Mr. W. R. Barclay, "The Development of Alloys of Nickel and Chromium for High Temperature Work and Electrical Resistance Heating."

University of London, University College, Gower Street, W.C. 5.30 p.m. Prof. G. Elliot Smith, "The Evolution of Man." 5.30 p.m. Prof. J. G. Robertson, "Swedish Literature in the Eighteenth Century." (Lecture I.)
5.30 p.m. Dr. E. A. Baker, "Methods of Reading."
At King's College, Strand, W.C. 5.30 p.m. Mons. Paul Fort, "Paris Sentimental." (In French.)
At the School of Oriental Studies, Finsbury Circus, E.C. 5 p.m. Prof. H. H. Dodwell, "Relations of the Civil and Military Powers at Madras in the 18th Century."

Royal Institute of Public Health, 37, Russell Square, W.C. 4 p.m. Dr. H. Gilford, "The Prevention of Cancer and Allied Neoplasias."

Eugenics Education Society, at the Royal Society, Burlington House, Piccadilly, W. 8.30 p.m. Rev. J. C. Pringle, "The Merx-Plas Labour Colony in Belgium."

Thursday, November 12..Royal Society, Burlington House, Piccadilly, W. 4.30 p.m.

Central Asian Society, at the Royal United Service Institution, Whitehall, S.W. 5 p.m. Lieut.-Col. W. G. Grey, "Recent Persian History."

Aeronautical Society, 7, Albemarle Street, W. 5.30 p.m. Mr. H. B. Howard, "Some Problems in Aeroplane Structural Design."

Electrical Engineers, Institution of (Irish Centre), at Trinity College, Dublin. 7.45 p.m. Mr. G. G. Sutcliffe, "Underground Telephone Construction."

(Dundee Sub-Centre), at University College, Dundee. 7.30 p.m. Mr. I. Sclar, "A Comparison of Electrical Wiring Installations and Analysis of their Costs."

Metals, Institute of (London Local Centre), at the Royal School of Mines, South Kensington, S.W. 7 p.m. Dr. R. S. Hutton and Dr. O. F. Hudson, "Science and Industry: Some Impressions from the Early Experiences of the British Non-Ferrous Metals Association."

Optical Society, at the Imperial College of Science, South Kensington, S.W. 7.30 p.m.

Child Study Society, 90, Buckingham Palace Road, S.W. 6 p.m. Mr. M. Yearsley, "The Development of Speech in the Normal Child."

London County Council, at the Geffrye Museum, Kingsland Road, E. 7.30 p.m. Mr. A. L. Howard, "Furniture Timber of India and Burma."

University of London, University College, Gower Street, W.C. 5.30 p.m. Major-General Sir George Aston, "The Study of War."
5.30 p.m. Dr. Camille Pellizzi, "Idealisti E Sensisti Sulla Fine del Settecento." (In Italian.)
At King's College, Strand, W.C. 5.15 p.m. Rev. N. Sykes, "The Social and Political Ideas of some Great Thinkers of the 16th and 17th Centuries." (Lecture IV.)—Richard Hooker."
5.30 p.m. Dr. E. Prestage, "The Role of Diplomacy in the Struggle between the Portuguese and Dutch for Brazil."
5.30 p.m. Sir Arthur Newsholme, "The Community and Social Hygiene."
5.30 p.m. Mr. C. Collins Baker, "Italian Painting: its Place in Art."
At the Birkbeck College, Fetter Lane, E.C. 5.30 p.m. Sir Henry Slesser, "Trade Union Law." (Lecture I.)

Friday, November 13..London Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 5 p.m. Sir Frank Baines, "The History and Preservation of Westminster Hall."

Engineering Inspection, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 7.30 p.m. Dr. W. H. Hatfield, "Modern Developments in Steels resistant to Corrosion."

Metals, Institute of (Local Centres), at the University, St. George's Square, Sheffield, 7.30 p.m. Mr. S. Field, "Recent Advances in Electro-Deposition."
At University College, Singleton Park, Swansea. 7.15 p.m. Mr. L. B. Pfeil, "Effect of Crystal Size on the Mechanical Properties of Metals."
Astronomical Society, Burlington House, Piccadilly, W. 5 p.m.
Physical Society, at the Imperial College of Science, South Kensington, S.W. 5 p.m.

Saturday, November 14..Transport, Institute of (N.E. Local Centre), Newcastle-on-Tyne. 3 p.m. Mr. C. J. Allen, "British main line passenger Train Services."

London County Council, at the Horniman Museum, Forest Hill, S.E. 3.30 p.m. Mr. R. A. Smith, "Aspects of Roman London. II."

JOURNAL OF THE ROYAL SOCIETY OF ARTS

No. 3807 VOL. LXXIII.

FRIDAY, NOVEMBER 6th, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

WEDNESDAY, NOVEMBER 11th, at 8.30 p.m. (Ordinary Meeting.) SIR CECIL HARCOURT-SMITH, C.V.O., LL.D., late Director and Secretary of the Victoria and Albert Museum, "The Modern Note in Industrial Art." (Trueman Wood Lecture.) THE RT. HON. THE EARL OF CRAWFORD AND BALCARRES, K.T., will preside. Tea and coffee will be served in the Library after the meeting.

Further particulars of the Society's meetings will be found at the end of this number.

REPRINT OF HOWARD LECTURES.

The Howard Lectures on "Motor Fuels," by J. S. S. Brame, F.I.C., F.C.S., Professor of Chemistry, Royal Naval College, Greenwich, and Past President, Institution of Petroleum Technologists, have been reprinted from the *Journal*, and the pamphlet (price 1*s.* 6*d.*) can be obtained from the Secretary, Royal Society of Arts, John Street, Adelphi, W.C.2.

A full list of the lectures which have been published separately and are still on sale, can also be obtained on application.

FRIESE-GREENE COLOUR FILMS.

A series of films entitled "The Open Road," which have been taken by the Friese-Greene Colour Process (a process explained to the Society by the author last session), will be shown at the London Pavilion on Sunday evening, November 29th. A number of tickets have been placed at the disposal of the Society. Fellows who desire to see the films should apply to the Secretary, on or before Monday, November 23rd. Not more than two tickets can be given to each Fellow.

PROCEEDINGS OF THE SOCIETY.

EIGHTEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 22ND, 1925.

MR. EMERY WALKER, F.S.A., in the Chair.

THE CHAIRMAN, in introducing the lecturer, said Mr. Chivers would be known to many of those present as perhaps the most important binder outside London, and as a binder who had perhaps more to do with library re-binding than anyone else in the trade; and he had been good enough to come that evening to state how he did it.

The paper read was:—

BOOKBINDING.

By CEDRIC CHIVERS, J.P.

Nearly 40 years ago my attention was called by a librarian to the difficulty he experienced in keeping books intact and in good enough condition for the purpose of loaning to his readers. On enquiry I heard that he paid 10d. per volume for a binding in half-leather fully lettered. It was impossible even in those days of cheap labour and material to do good work at the price. The sewing, the end-papers and all out of sight work was scamped and only the appearance of the book as a suitable binding was supplied. I was asked to take up the matter and make out a specification for a properly bound and serviceable book. I was able to show and produce a binding for 1s. 7d. which had all the serviceable qualities to be desired.

This specification was widely published and is still in force in many Libraries although the conditions of paper to-day make it in many respects most undesirable. Indeed I frequently lose contracts for Library binding because of my refusal to follow the instructions of a specification which under other conditions I personally drew up.

These methods were the best which at that time could be contrived, but presently complaints began to be made as to the durability of some of my bindings. Pages broke away from the sewing. This I remedied by a new system of oversewing. While trying to improve the methods and materials of bookbinding it became apparent that something inimical existed, and I found that the paper of modern books was so bad that traditional methods of sewing and binding were ineffective. A modern bookbinding is necessary to meet the needs of modern papers. The old method of sewing through the folded section was right for the quality of paper to be sewed, but I found it wrong for much modern paper, which is so bad that it loses one half of its strength in the act of creasing it in the fold.

Fig. 1 shows a photomicrograph of the edge of a piece of an inferior paper which has been folded *once only*. The crease due to the folding is clearly

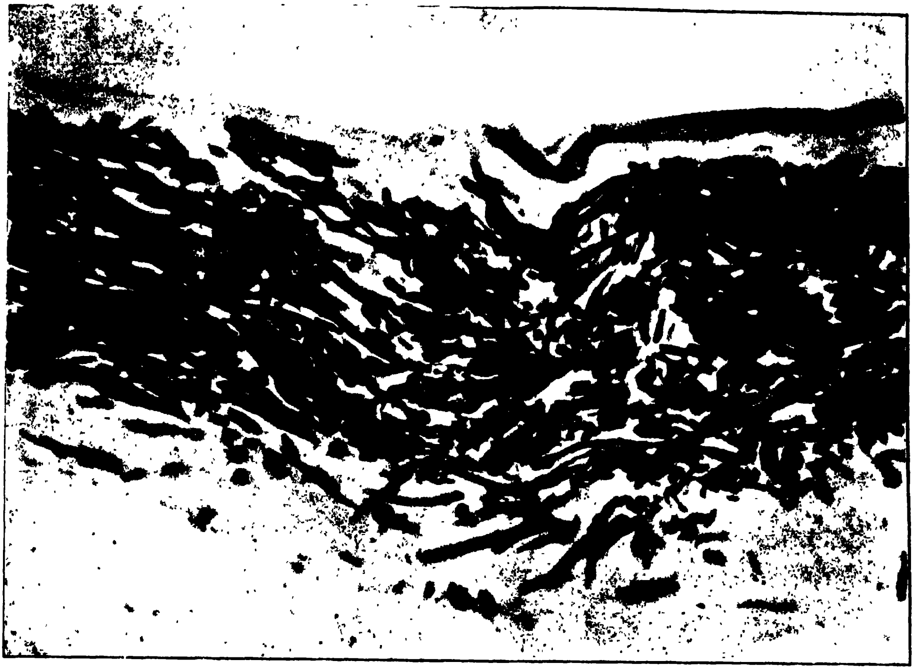
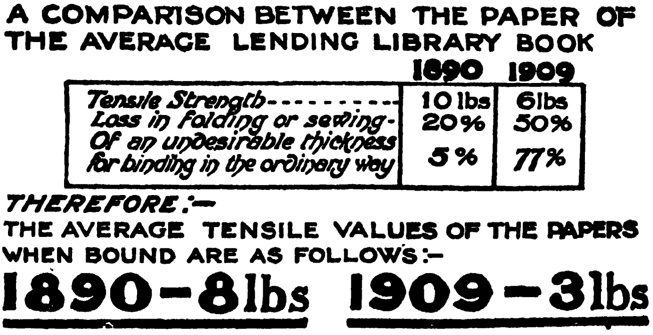


FIG. 1.

shown. It is through this broken fibre that the sewing was done, and the book had to depend on it for its strength. It has become necessary therefore for the bookbinder to discover the kind of paper to be bound, and adapt his methods accordingly.

From a great number of tests made on papers used for fiction during a period of twenty years the deterioration shown was from 10 lbs. to 6 lbs. in tensile strength (Fig. 2). The more modern papers actually lose half their strength in folding, and, plus this deterioration, the modern binder has to contend with



A COMPARISON BETWEEN THE PAPER OF THE AVERAGE LENDING LIBRARY BOOK

	1890	1909
Tensile Strength ---------	10 lbs	6lbs
Loss in folding or sewing -	20%	50%
Of an undesirable thickness for binding in the ordinary way	5%	77%

THEREFORE:—
THE AVERAGE TENSILE VALUES OF THE PAPERS WHEN BOUND ARE AS FOLLOWS:—

1890–8lbs 1909–3lbs

FIG. 2.

77% of papers of undesirable thickness for binding in the ordinary way, against his predecessor's but 5%.

In machine-made paper the fibre is drawn in one direction—this direction is consequently the strongest. Fig. 3 shows a portion of the surface of a roll of paper, the width of which is indicated by the two thick lines. A sheet of double crown paper cut in the vertical from B would when folded in 8vo have the grain in the direction shown by the arrows and the paper would be stronger in this direction than it would be if cut as A. The latter when folded would have the strong direction up and down the page of the book, and consequently it would be weak in the fold.

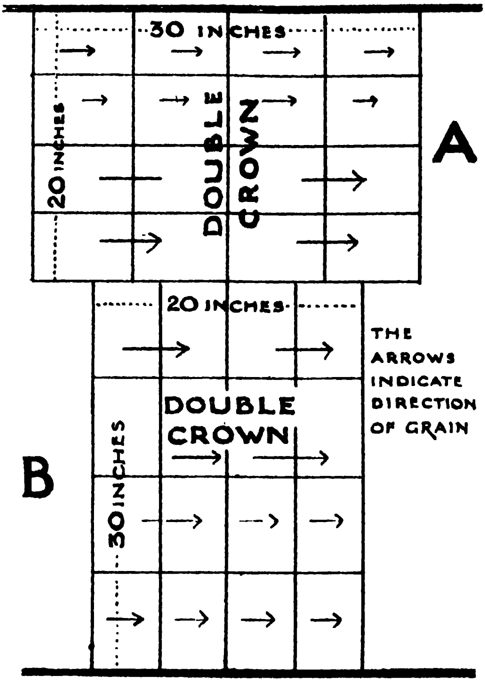


FIG. 3.

It had become necessary to learn something about the grain or fibrous direction of the paper. A book sewed through the folded paper may serve well if the grain be across the page, but the same paper would make a weak binding if served in the same manner with the grain running the length of the book. The bookbinder, if he has determined the direction of the grain, may turn the disadvantage of a weak direction to a desirable thing. If the paper be thin it is at least pliable, and while it would be fatal to sew it through the fold, it might be carefully oversewed with advantage. In the course of examining the direction of the grain in the papers of modern books, it was interesting to note that the folding conditions of paper were much better in

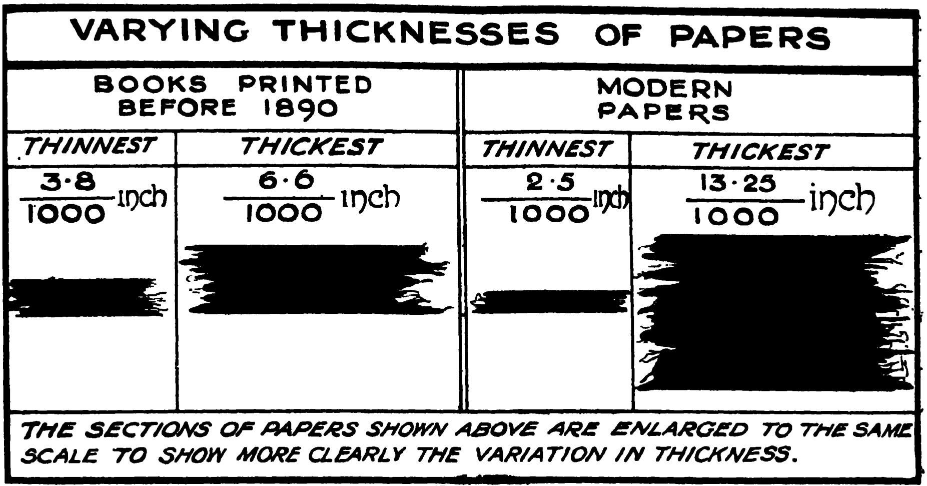
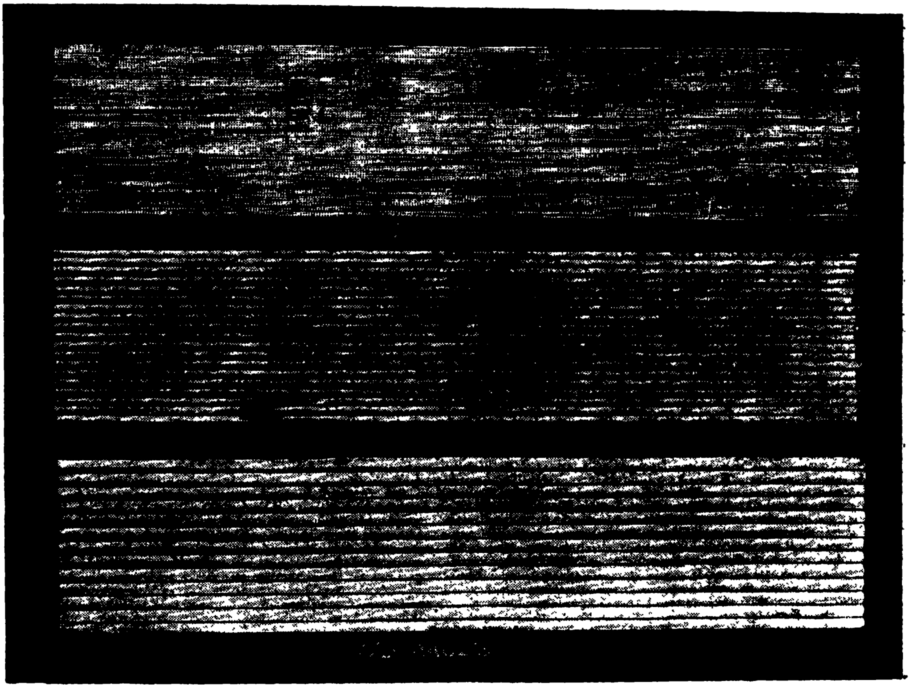

VARYING THICKNESSES OF PAPERS
BOOKS PRINTED BEFORE 1890
MODERN PAPERS
THINNEST
THICKEST
THINNEST
THICKEST
3·8/1000 inch
6·6/1000 inch
2·5/1000 inch
13·25/1000 inch
THE SECTIONS OF PAPERS SHOWN ABOVE ARE ENLARGED TO THE SAME SCALE TO SHOW MORE CLEARLY THE VARIATION IN THICKNESS.

FIG. 4.



1168 pages composed of 73 sections of 16 pages each.
304 pages composed of 19 sections of 16 pages each.
416 pages composed of 13 sections of 32 pages each.

FIG. 5.

English-produced volumes than in those coming from America, of which no less than 86% had the grain running in the weak direction.

Another factor the binder must take into consideration is that of thickness. Fig. 4 shows the largely increased range of thicknesses of paper the binder has to contend with, and it is obvious that while the same specification might serve for books before 1890, it becomes impossible with modern papers.

Apart from the thicknesses and qualities of the paper I observed greater variations in the thicknesses of the sections of modern books as compared with those of 1890. The number of leaves in a section must be made to depend upon the thickness of paper. Oversewing makes this possible.

Fig. 5 shows the backs of three books folded and ready for sewing. To bind these three books in the same way would bring about disastrous results—different treatment must be applied in each case.

The greater variation in the qualities of modern books as compared with those of 1890 is shown in Fig. 6. It is clear how necessary it is for bindings to be adapted to the varying conditions shown in the diagram.

The fact that the paper of books has deteriorated in wearing qualities no less than 60% demonstrates the futility of employing bookbinding methods of

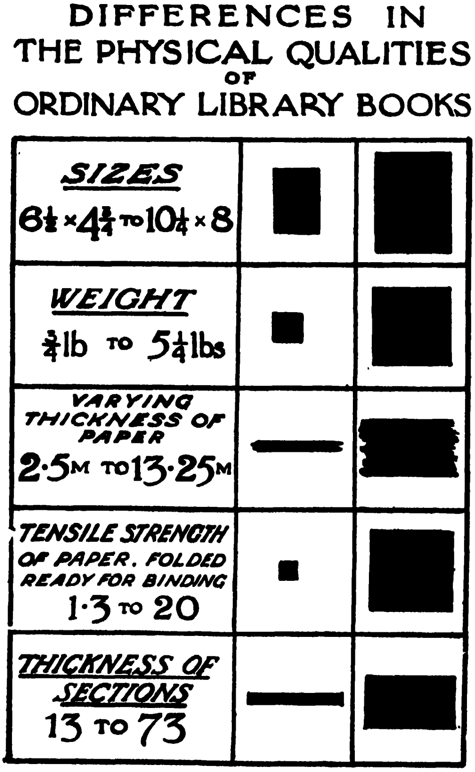


FIG. 6.

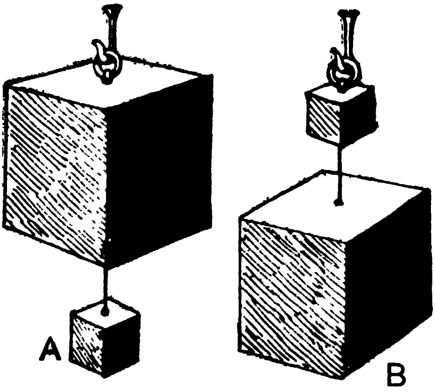


Fig. 7.

1890 at the present day. Fig. 7 illustrates the difference between bookbinding conditions of 30 years ago and those of to-day. The connecting rope represents the bookbinding. A connection which will hold the smaller weight A is seen to be quite inadequate to hold the larger weight B.

With oversewing when properly done, the paper is not weakened nearly so much—with the unfolded sheet pierced for oversewing the loss is only 16% as against 48% with the sheet folded and pierced for sewing through. One other great advantage of oversewing papers suitable for the method is that the paper is not doubled acutely thereby, breaking the fibres (fig. 8). My own oversewing is so arranged that each section is sewed through the previous two sections, making the book intact. The pliable weak modern papers treated this way serve as well as the leaves of better books.

One of my first efforts to reform bookbinding methods was to construct a new end paper. Hitherto it was merely a folded sheet pasted on the first and last leaves of the book, giving no greater strength than the paper joint afforded. It had the bad effect of stiffening the fold of the first leaf of the book—this was either the half-title or title of the book, which in nine cases out of ten broke away after a very little use. (So bad was this that in a Public Lending Library it would be hard to find a book which was intact in its binding at that time). I contrived an end paper of double linen joint which was independently sewed on, and instead of being a strain on the first and last leaves of the book, protected these, the most used leaves, strengthening them as well as the attachment of the cover to the book. This method of end-papering and jointing the cover of the book is now universally demanded and used in all the Public Libraries of Great Britain and America.

Books were originally sewed on strings; these were frequently weakened and broken in hammering them into their boards. Tapes replaced string and these have now become unnecessary in books with tight backs, the leather of which tightly holds the book together; moreover the use of tapes entails extra work

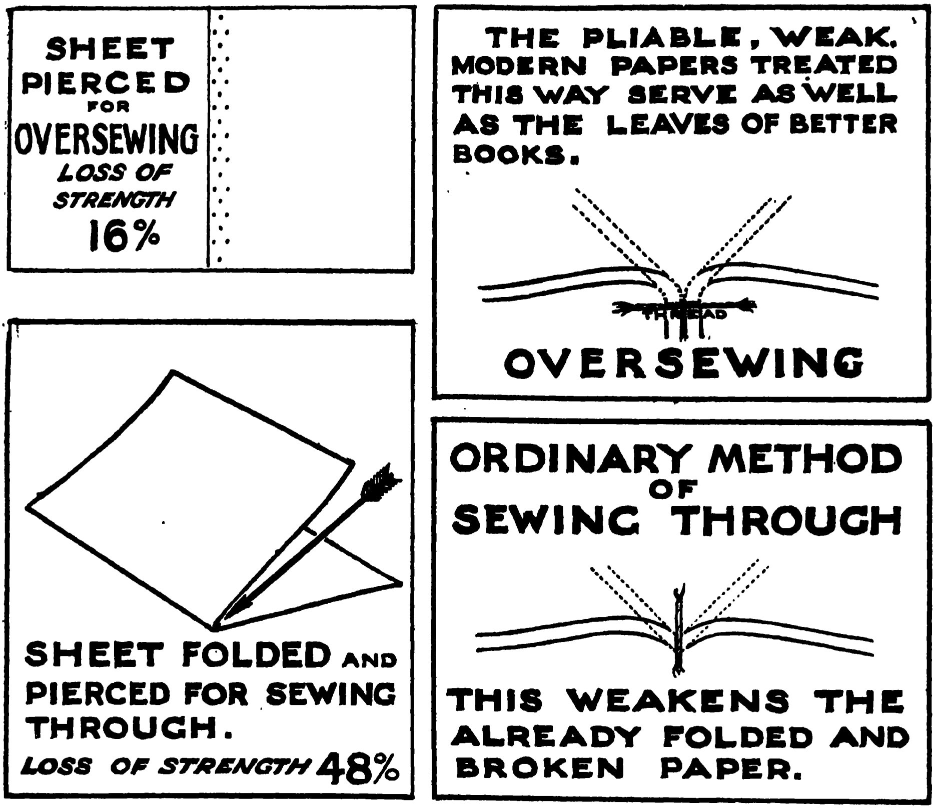

SHEET PIERCED FOR OVERSEWING
LOSS OF STRENGTH 16%
THE PLIABLE, WEAK, MODERN PAPERS TREATED THIS WAY SERVE AS WELL AS THE LEAVES OF BETTER BOOKS.
THREAD
OVERSEWING
SHEET FOLDED AND PIERCED FOR SEWING THROUGH.
LOSS OF STRENGTH 48%
ORDINARY METHOD OF SEWING THROUGH
THIS WEAKENS THE ALREADY FOLDED AND BROKEN PAPER.

Fig. 8.

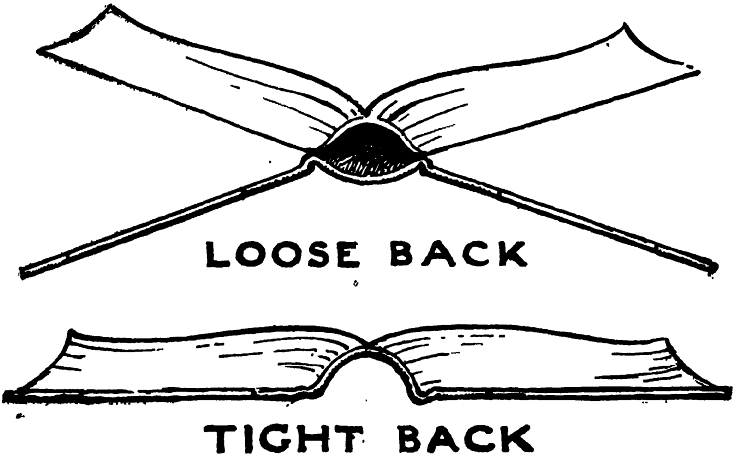

LOOSE BACK
TIGHT BACK

Fig. 9.

and expense, whilst hindering the free flow of glue and causing excrescences on the surface of the back. One point in the excellent Report of the Royal Society of Arts, I think, is open to criticism, in the recommendation of the use of "four unbleached linen tapes." Specifications founded on that Report, insisting on tapes for all books alike, disregard the fact that the binding of a book must be adapted to the individual needs of its paper if it is to render good service.

The difference between a tight and loose back is shown in Fig. 9. It will be noticed that in the case of the loose back the leather is in contact with the book at two points only; this means the joints are strained and covers soon become detached. A tight back more effectively binds a book, for the leather grips the whole surface of the back, and every section is tightly held.

The leaves of books of thick pulpy paper I now actually strengthen, fortifying the fibre. by re-sizing and pressing, so that a better surface results, less spongy and less absorbent. A book so treated gives a far longer service, and by reason of the improved surface of its paper remains clean longer.

Books of very stiff paper, books of plates on thick paper have hitherto been difficult to bind satisfactorily. By a method of bending the leaves in one or more places some ¾ inch from the back it is possible to make such books open quite freely. Fig. 10 shows a book too bad to sew through and too stiff to

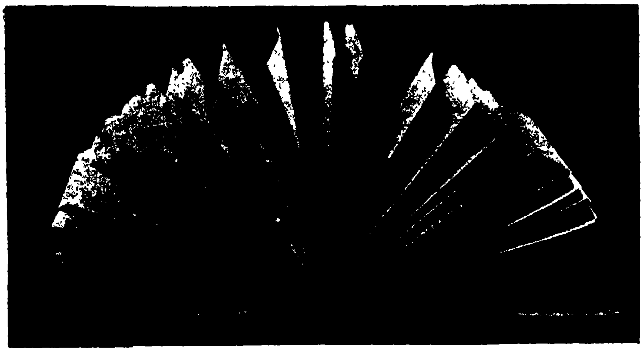


Fig. 10.

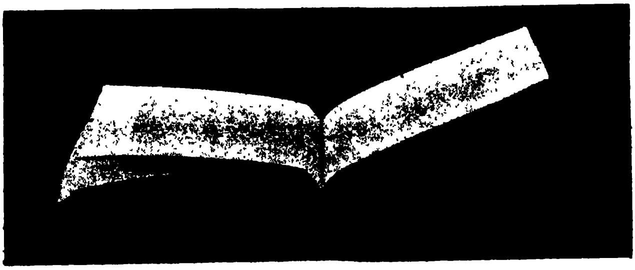


Fig. 11.

oversew. It rapidly breaks and soon soils, since so much handling is necessary to use it. Fig. 11 shows a similar book oversewed and bent. This method is useful for all books of thick paper with sufficient margins. In the case of Fig. 12, which has narrow margins, the leaves have been strengthened by sizing and sewed through the back, each leaf bent to ensure ease of opening. Better facility for handling is assured and the life of the book is much prolonged.

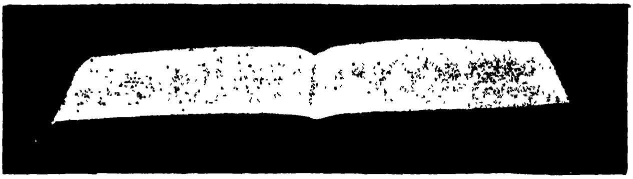


FIG. 12.

For books of thick paper requiring guarding I use a serrated linen (Fig. 13). This has advantages over the usual method, in that it is cheaper, is more readily pressed into the paper, and the serrations are so arranged as to interlock, resulting in less thickening at the back of the back than with the usual method.

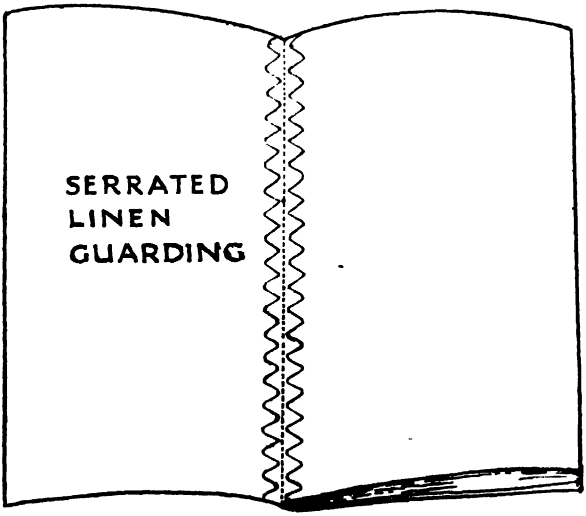
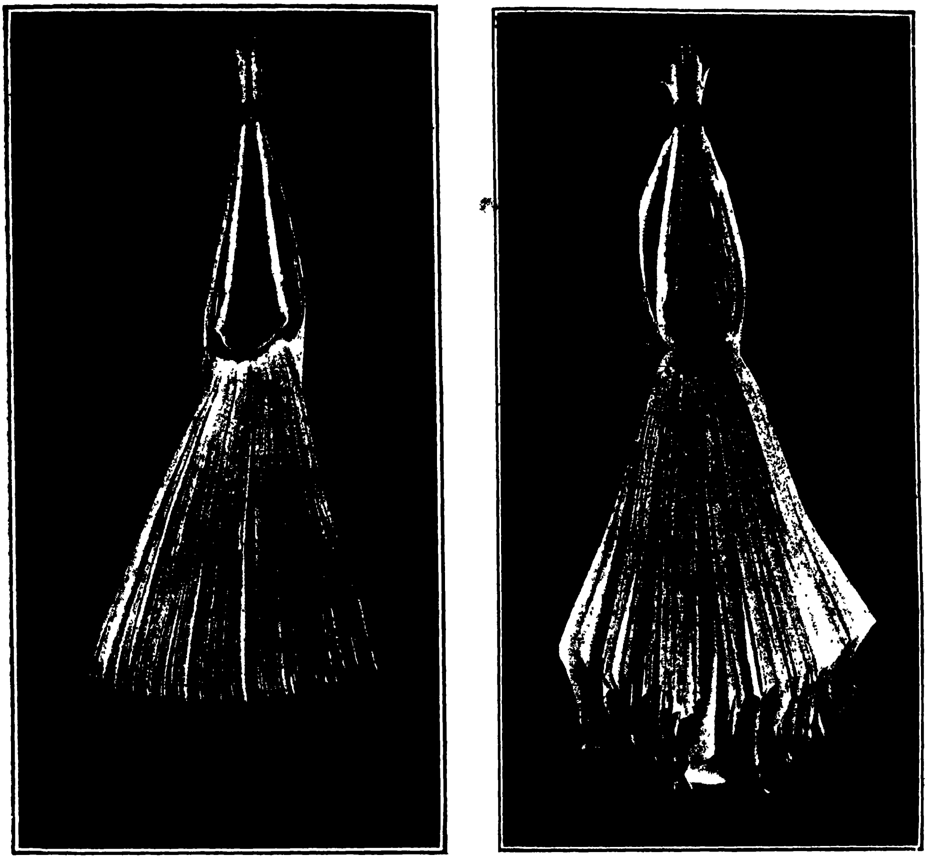


FIG. 13.

For books not greatly used but required for permanent reference, I have provided a binding which I call " Storage Binding." It has been made possible by large purchases of Niger leather, using the rougher surfaced portions of skins for this cheaper work, by machine sewing and the employment of a specially made hard grained board which does not require a cloth covering. This supplies a cheap binding which is efficient for the purpose for which it is intended—for Patent Specifications, Parliamentary Blue Books and such books



A Fig. 14. B

as one would hesitate to put in a binding too good for the service required of them.

The photograph (Fig. 14) shows in a graphic way the result of binding all books in the same way. The book A has sustained no less than 483 issues in a Public Library, whereas B has come to pieces after being loaned some 10 times only. It was bound in exactly the same way as A. This illustrates the necessity of adapting the binding to the varying qualities of paper. Had the nature of the paper of B been considered and appropriately dealt with it would have rendered good service.

Leather has qualities which no other materials possess in adaptability to the binding and covering of books. Other materials may cover but they do not bind as leather does—if wisely chosen it has greater variety in thickness, softness, pliability, tenacity of adhesion and strength, being capable of adaptation to the exceedingly varied conditions which the diagrams illustrate modern books to exhibit. The Society of Arts in 1901 gave a very valuable report on the reasons for the decay observed in modern leather and set forth suggestions as to the better tanning and dyeing. Some amplification of their enquiry appears to be necessary, for supposing the leather is tanned and dyed in the manner the report specifies, it is still desirable to know which leathers supply the best mechanical qualities. I therefore made exhaustive tests of the tearing strains of the various leathers used in bookbinding. Fig. 15 sets out the results of such tests; first the thickness in thousandths of an inch is given, then the tearing strain in pounds. The strength ratio is shown and the order of value of the skins compared with each other. The high value which is shown by the Niger leathers is not a little surprising, when it is remembered that these leathers have been tanned by the natives of Nigeria. The Nigerian tanner, in his so-called ignorance, has been working along the lines of least resistance, allowing atmospheric conditions, temperature and time to operate, with results which give a more satisfactory result than can be obtained under civilized conditions. Figs. 16 and 17 are photomicrographs of the transverse sections of various leathers; these have been prepared with the object of visualizing and examining the fibres of different leathers, comparing their proportions of muscular tissue, and showing the interlocking of the tissues, which are strongest next to, that is, lying next to the animal's body; as the latter are pared away so the tensile strength of a skin is reduced.

Further severe tests under extreme conditions of heat, dryness and moisture have demonstrated that the native tanning of Nigerian leather more effectually preserves it from injury under bad conditions. Under conditions in which

Cowhide and calf ...	lost	99%	of its	original	strength,
French Levant Morocco...	...	87%	,,	,,	,,
Persian hard grain Morocco	...	83%	,,	,,	,,
Thin Pigskin	...	75%	,,	,,	,,
Morocco	...	70%	,,	,,	,,
Thick Calf	...	50%	,,	,,	,,
Thick Hogskin	...	27.8%	,,	,,	,,
Niger Leather	...	12%	,,	,,	,,

So that with the linen jointed end paper, improved oversewing, methods of dealing with refractory papers and the leather free from acid and the best kind of skin for bookbinding purposes being selected, it is now possible to produce a binding which lasts the very much lengthened life of the book. Bookbinding can effectively be made to hold and protect modern books for Library service, if it is adapted to the many different qualities of paper now used, and allied with materials and leathers specially selected and prepared to give hard and long usage.

A passing reference to the decorated book cover may be of interest. A method of covering original water colour designs with transparent vellum makes possible for the first time the use of colour in a permanent form for the

TEARING STRAINS OF VARIOUS LEATHERS.

SIZE OF PIECE TESTED 2¼ inch × 1¾ inch.

Ref. No.	LEATHER TESTED.	THICKNESS in 1000th of in. A	B	C	TOTAL	TEARING STRAIN in lbs. A	B	C	TOTAL	Strength Ratio	Order of Value
9	Niger Leather (un-pared)	70	65	55	190	63	81	45	189	·99	2
2	Niger Leather (goat)	45	40	39	124	31	40	32	103	·83	4
—	" " (sheep)	40	40	36	116	36	41	35	112	·96	3
—	" " (pared)	32	33	33	98	33	21	20	74	·75	5
1	Soft Niger Leather	21	21	20	62	16	16	12	44	·70	6
11	Imitation Niger Leather	29	29	30	88	9	7	11	27	·30	15
—	Ditto	29	29	29	87	10	11	10	31	·35	14
—	Thick Levant (un-pared)	87	80	75	242	36	24	37	97	·40	13
3	Levant Morocco	50	55	50	155	20	21	22	63	·40	13
14	Ditto	45	48	45	98	10	10	9	29	·29	16
10	Ditto	55	50	50	155	35	35	28	98	·63	7
7	Morocco (thick)	70	57	55	182	29	21	23	73	·40	13
5	Morocco (thin)	37	37	39	113	15	16	19	50	·44	11
13	HardGrain'd PersianGoat	31	32	34	97	19	20	12	51	·52	10
6	Pigskin	36	34	32	102	14	18	11	43	·42	12
12	Pigskin	33	30	30	93	26	13	15	54	·58	8
—	Seal	40	45	36	121	23	23	20	66	·54	9
8	Roan	22	22	23	67	20	15	12	47	·70	6
—	Cowhide	23	25	18	66	5	5	4½	14½	·21	18
—	Cowhide	12	12	12	36	4	2¾	2½	9¼	·25	17
4	Calf	25	23	32	80	6	5	6½	17½	·21	18
—	Vellum	10	10	18	38	11	14	20	45	1·18	1

ODD PIECES OF BOOKBINDERS LEATHERS TESTED.

	Morocco	34	—	—	34	12	—	—	12	·35	
	Ditto	35	—	—	35	20	—	—	20	·57	
	Ditto	31	—	—	31	16	—	—	16	·51	
	Ditto	23	—	—	23	6	—	—	6	·26	
	Law Sheep	38	—	—	38	6	—	—	6	·15	
	Cowhide	28	—	—	28	5	—	—	5	·17	
	Ditto	33	—	—	33	7	—	—	7	·21	

FIG. 15.

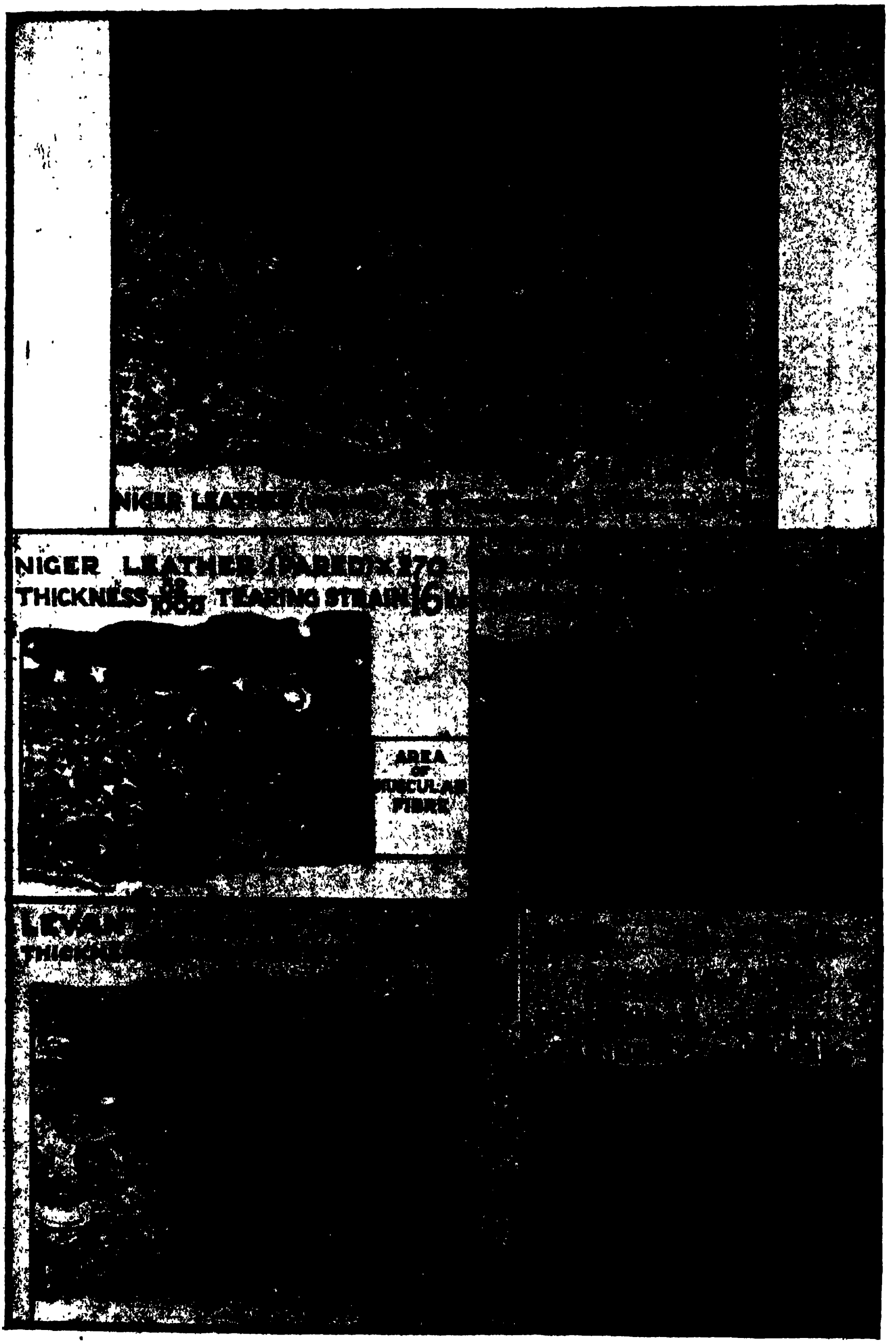

NIGER LEATHER
NIGER LEATHER (PARED) × 170
THICKNESS 18/1000 TEARING STRAIN 16
AREA OF MUSCULAR FIBRE
LEVAN
THICKN

FIG. 10.

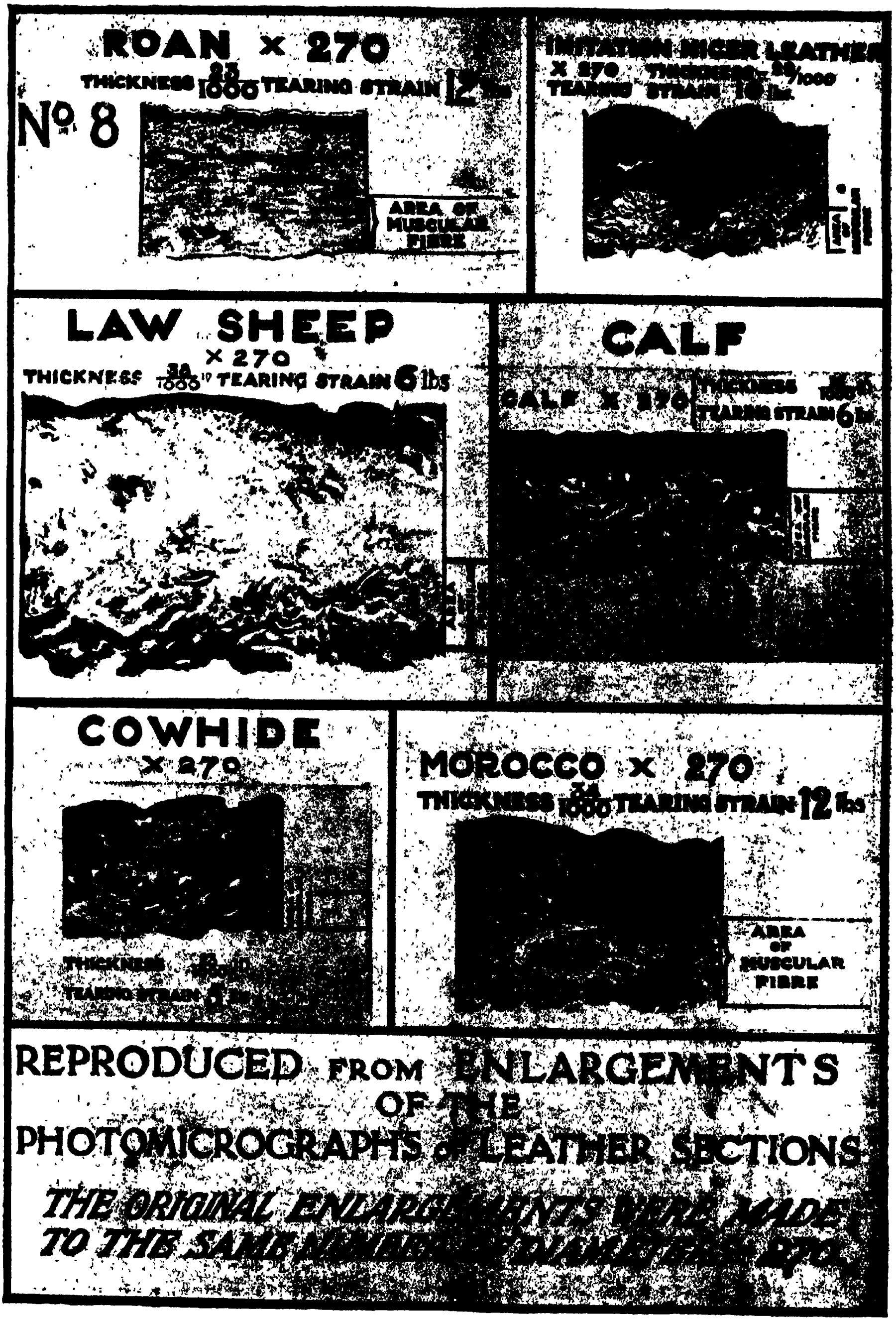

ROAN × 270
THICKNESS 23/1000 TEARING STRAIN 12 lbs
Nº 8
AREA OF MUSCULAR FIBRE
IMITATION NIGER LEATHER
× 270 THICKNESS 23/1000
TEARING STRAIN 10 lbs
LAW SHEEP
× 270
THICKNESS 38/1000" TEARING STRAIN 6 lbs
CALF
CALF × 270
THICKNESS
TEARING STRAIN 6 lbs
COWHIDE
× 270
THICKNESS
TEARING STRAIN 6 lbs
MOROCCO × 270
THICKNESS 34/1000 TEARING STRAIN 12 lbs
AREA OF MUSCULAR FIBRE
REPRODUCED FROM ENLARGEMENTS OF THE PHOTOMICROGRAPHS of LEATHER SECTIONS
THE ORIGINAL ENLARGEMENTS WERE MADE TO THE SAME NUMBER OF DIAMETERS 270

FIG. 17. 2

external decoration of books. The design is painted upon paper which is covered with transparent vellum (the unstretched skin), the surface of which is tooled with gold. A book bound in this " Vellucent " binding is shown in Fig. 18. This form of decoration may be used in connection with leather bound books; vellucent panels are inlaid in the leather cover amid surrounding gold tooling. Fig. 19 illustrates a volume so bound. Such a treatment is specially adaptable to Illuminated Addresses in book form, as the panels may be designed to have intimate personal application to the recipient. Old and valuable books may be suitably rebound by reproducing the age and character of the title pages and covering with the transparent vellum. An old and decayed leather binding effectively restored, and its decay arrested (being protected from atmospheric influence) by covering the entire surface of the leather with the vellum while still retaining every detail of the binding and its old appearance, is shown in Fig. 20.

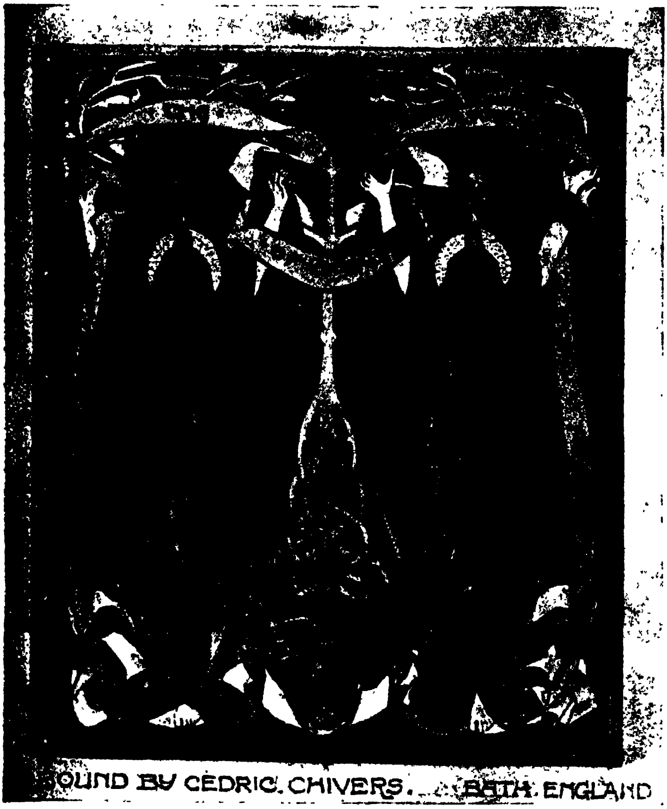


FIG. 18.

FIG. 19.

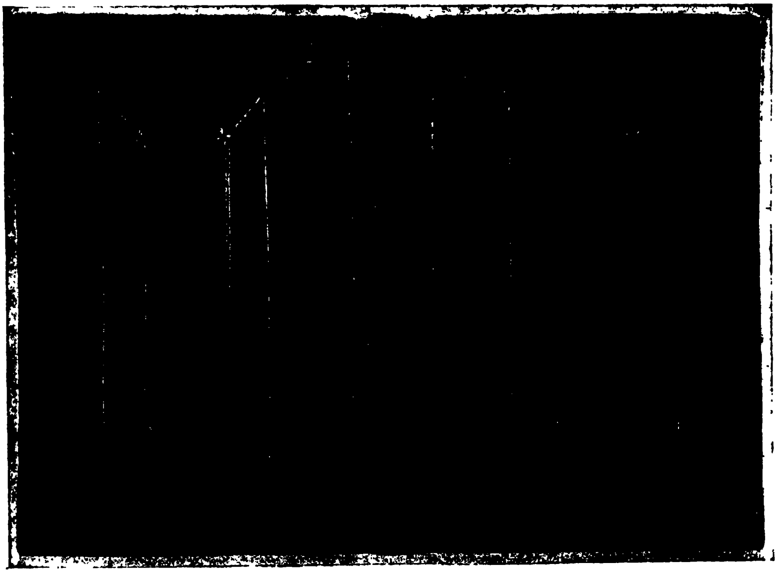


FIG. 20.

DISCUSSION.

The Chairman, in opening the discussion, said he thought it might be said that the earlier part of the lecture had been chiefly devoted to showing how to make the best of a bad job. Surely the right thing to do was to use a paper which did not require to be re-sized before the book was re-bound ? Paper had steadily got worse in his own time. At the beginning of the last century machine-made paper had taken the place of hand-made paper. Books which authors and publishers wanted to do their duty by had always been printed on hand-made paper. The difference between hand-made paper and machine-made paper, in its manufacture, was that in the machine-made paper the pulp flowed from the vat all in one direction, and therefore, the paper was very easily torn in the direction of the flow of pulp. With regard to a hand-made paper, the paper-maker dipped the mould, a wire sieve, into the pulp and gave it a shake, which interlocked the fibres in all directions. If one employed the same material which was used for a hand-made paper on a machine, one could get a very good paper indeed, but it did lack the quality given by the fibre being interlocked in all directions. Machine-made writing paper would tear very much more readily in one direction than in the other, and that was not so with a hand-made paper.

Mr. F. Pacy (Library Association) said although Mr. Chivers had been talking on the subject for a great many years past, he always had something new to say about it: Mr. Chivers was an inventive genius. He would like to ask whether the Niger morocco, to which Mr. Chivers had referred, suffered by being dyed in different colours. Was there an acid, or deterioration ? He asked that question because long before the Royal Society of Arts specification, under the guidance of Mr. Hume of the Patent Office he had been contracting for acid-free leathers, but those leathers had all gone to rot at the end of 25 or 30 years. He was perfectly convinced that in a great many of those colours acid had been used, in spite of the specification which laid down that it should not be used.

He agreed that it would be best to leave the leather binding in its natural colour, but he was afraid that the Public Libraries would present a very dull atmosphere if it were so left; a library would present the deadly monotony of a collection of Hansard debates. The atmosphere of a library depended very much upon the decoration on the books.

Mr. Chivers said he had found that the dyes used in dealing with Niger leather were harmful, and therefore he did not allow anybody but himself to dye the leather which he used. On one occasion he had got one firm to guarantee him £100 if they did anything to the leather which was harmful. He had analysed that leather and had found that the firm had put in harmful constituents, but although he had applied for his £100 he could not get it. He had, therefore, determined that in future he would always do the dyeing himself.

Mr. R. à-Ababrelton remarked that he had in his possession a number of old family bibles. Such bibles as a rule were bound with leather-covered millboards. The leather as a rule was very bad indeed, and was decayed. Personally, he had been able to do something to the leather which, in his opinion, would make it last for a good many years to come. He would like to ask Mr. Chivers whether he had done anything in the direction of preserving the leather.

Mr. Chivers said the matter which Mr. à-Ababrelton had raised had often been before the Library Association, which had discussed it, and which had recommended several things for the purpose of nourishing the leather. When leather got dry no strength could be put into it.

Mr. à-Ababrelton said he thought that was not the case, because he had done it.

Mr. Chivers said if Mr. à-Ababrelton had any method to suggest, the Library Association would be only too glad to hear about it and recommend it.

A Member of the Audience asked if gas in libraries was very injurious to the coverings of books and whether all Public Libraries should not use electric light.

Mr. Chivers replied that gas was exceedingly injurious, but in the last few years the condition of the atmosphere in libraries had been vastly improved, and the books would have a much better chance in the future.

Mr. Stanley Unwin asked if Mr. Chivers had noticed any tendency during the last year or two amongst publishers to use rather better quality papers. There had been a period before the war when bulk had been the fetish. He was hoping that that fetish had not now quite the strong hold that it then had had.

Mr. Chivers replied that he thought paper was improving.

A Member of the Audience asked if Mr. Chivers thought that leather, even Niger leather, was the best thing for binding books which were simply put on library shelves and probably left there for ever. Would it not be rather better to use a fabric, such as a good buckram, for such books ? In the British Museum there were hundreds of fabrics thousands of years old, but there were no leathers of anything like that age. A fabric would probably last a good many centuries, whereas leather would certainly decay.

Mr. Chivers said that no fabric of which he knew bound a book. Leather was the only thing which bound a book. In his own opinion, Niger leather showed all the qualities of the old-fashioned leather, and would last hundreds of years. It was by far the best binding because it was the only thing which really did bind.

Mr. Albert E. Coles said at the time when the Society's report on bookbinding had appeared (at which time he was working for a library) he had been passing the Law Courts in the Strand and had found that new stones were being put in the building. He had enquired the reason and had been told that the repairs were necessary because of the climate and the sulphurous gases in the atmosphere. He had started using the Niger morocco leather at that time, and had cut out sections and had stuck them up on the wall in front of the light, within a few yards of Fleet Street. Ten years afterwards he had found that they had all gone to pieces. He had been assured that in the country of origin of that Niger leather many books of the Koran had been bound 200 years ago with it, and it did not show any signs of deterioration whatever. His own opinion was that the climate of London, with its gases, was bound to deteriorate that leather.

Mr. Chivers said he admitted that Niger leather deteriorated under free sulphuric acid, but he claimed for it, under the conditions he recommended, that it was better than anything else of which he knew.

ANOTHER MEMBER OF THE AUDIENCE said he would like to refer to oversewing. He noticed that one of the books which had been passed round that evening was not oversewn, and it had a hollow back. He assumed from that that Mr. Chivers did not advocate oversewing in all cases. The book in question had a beautiful paper.

MR. CHIVERS said he had been trying to make it clear all through his lecture that every kind of paper must be dealt with according to its needs, and that it was better to sew a book through if the paper was good enough; that was the proper way to bind a book. He did not criticise the binding of ancient books; they were bound excellently well. What he had tried to point out was that paper was becoming a very different kind of thing from what it used to be. The whole point of his lecture had been that paper varied so much that it required various methods in dealing with it.

MR. W. H. DYER said it had been particularly interesting to him to listen to Mr. Chivers's review of the methods of library binding, in the light of his own experience, which went back for many years. He remembered the indifference with which library binding was treated by the buyers of library books. He knew a firm for which he used to work who thought it quite met the case to purchase the off cuts and cuttings from an upholsterer, and, whether the leather was thick or thin, it was put on to library books. The result was disastrous, because those books used to be returned in a very dilapidated state. Even if the binding of a book cost double, it was in the end an economical advantage to pay that double cost. Mr. Chivers conducted his library binding on a scientific and economical basis. He had no rival in that class of work. His relations with his workpeople were of a very happy character, and it was because of that relationship that Mr. Chivers obtained the good results he did. In his own opinion, but for that fact, Mr. Chivers would not, perhaps, have achieved the fame that he had.

MR. J. F. RONCA (Board of Trade) said that a question had been asked with reference to gas, and he gathered it was more or less definitely proved that gas was injurious to book-bindings. He was not a librarian or a bookbinder, but he was a little interested in chemistry, and he found rather a difficulty in realising how it could be absolutely determined that gas was injurious to bookbinding. He might say in passing that he was also not interested in gas. In existing conditions, gas as distributed had to be purified to a very high degree, and the bulk of the sulphur had to be taken out of it. On the other hand coal, as it was now burned all through the large cities, contained 1 per cent. and more of sulphur, all of which went into the air. The amount of sulphuric acid which went into the air from coal must be millions of times greater than that which went into the air from coal gas, and he could not help feeling that the acid trouble was not a gas trouble but a coal trouble. In a way, the man who was using electric light and who was buying it from a company generating from coal, was responsible for putting more sulphur into the air than was the man who lit his library with gas. He gathered that Mr. Chivers did not submit that dyes injured leather, but rather that it was the method of dyeing which injured the leather; it was not the dye itself but it was the method of applying the dye.

MR. PACY said he took it that Mr. Chivers practically recommended the scrapping of all specifications. If so, he thoroughly agreed with him, because all of them varied, and they laid down conditions in regard to which it was impossible for the binder to exercise his discretion. He was not referring to the Royal Society of Arts specification. His experience bore out what Mr. Chivers had stated, namely, that until people ceased to light libraries by gas the books would perish in enormous quantities.

MR. CHIVERS said with regard to specifications, he hoped he had shown that it was absolutely impossible to draw up a specification for the instruction of a bookbinder. One of the largest municipal libraries sent out a specification which was absolutely impossible to fulfil. One condition in it was that a split best English black board must be used. Nobody ever split a best English black board. It was impossible to do it; but one had to do it if one wanted to get an order from that particular library. There were other similar points in that particular specification. If one were to do what that specification laid down the books would be absolutely spoilt. When he had pointed those matters out to the particular librarian concerned he had been told that he was a man of sense and that he would not be asked to do anything impossible.

A vote of thanks to Mr. Chivers for his lecture terminated the meeting.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock (unless otherwise announced):—

NOVEMBER 11.—At 8.30 p.m.—SIR CECIL HARCOURT-SMITH, C.V.O., LL.D., late Director and Secretary of the Victoria and Albert Museum, "The Modern Note in Industrial Art." (Trueman Wood Lecture.) THE RIGHT HON. THE EARL OF CRAWFORD AND BALCARRES, K.T., will preside.

NOVEMBER 18.—I. C. GOODISON, of H.M. Office of Works, "The Furniture of Hampton Court and other Royal Palaces." H. AVRAY TIPPING, F.S.A., will preside.

NOVEMBER 25.—DAVID GREENHILL, General Manager, The Sun Engraving Company, Ltd., "Colour Printing." SIR ERNEST HODDER-WILLIAMS, C.V.O., will preside.

DECEMBER 2.—LIEUT.-COLONEL SIR ALAN H. BURGOYNE, M.P., A.M.Inst.A.E., "The Future of the Motor Car." COLONEL SIR THOMAS A. POLSON, K.B.E., C.M.G., M.P., will preside.

DECEMBER 9.—At 4.30 p.m.—(Joint Meeting of the Indian and Dominions and Colonies Sections.)—A paper on "The Imperial College of Tropical Agriculture," by H. MARTIN LEAKE, M.A., Sc.D., F.L.S., Director of the College, will, in the absence of the Author, be read by ARTHUR WILLIAM HILL, Sc.D., F.R.S., Director, Royal Botanic Gardens, Kew. The RT. HON. L. S. AMERY, M.P., Secretary of State for the Colonies, will preside.

INDIAN SECTION.

FRIDAY, NOVEMBER 20, at 4.30 p.m.:—

PROFESSOR EDWARD PERCY STEBBING, M.A., F.L.S., Professor of Forestry, University of Edinburgh, "Recent Progress in Indian Forestry." LT.-COLONEL SIR DAVID PRAIN, C.M.G., C.I.E., M.B., LL.D., F.R.S., will preside.

DOMINIONS AND COLONIES SECTION.

TUESDAY, NOVEMBER 24th, at 4.30 p.m.

MRS. JULIA HENSHAW, F.R.G.S., C.de G., Director of National Parks Association, Canada, " The Canadian National Parks." The lecture will be fully illustrated with slides painted by the author. (Dr. Mann Lecture.)

PAPERS TO BE READ AFTER CHRISTMAS.

Dates to be hereafter announced :—

PROFESSOR JOHN McLEAN THOMPSON, D.Sc., F.R.S.E., Professor of Botany, University of Liverpool, " Some General Problems of Fruit Preservation." (Aldred Lecture.)

JAMES EDWARD TAYLOR, M.I.E.E., Superintending Engineer, Post Office Telegraphs, etc., South Midland District, " The Propagation of Electric Waves."

H. HOULSTON MORGAN, Ph.D., B.Sc., F.C.S., President, Oil and Colour Chemists' Association, " Problems in Paint and Varnish Technology."

C. F. ELWELL, B.A., " Progress in Radiotelegraphy : A Survey of Accomplishment and Possibilities of Future Development."

SIR EDWARD JOHN RUSSELL, O.B.E., D.Sc., F.R.S., Director, Rothamsted Experimental Station, " Investigations in Agricultural Science at Rothamsted." THE RIGHT HON. LORD CLINTON, Chairman, Lawes Agricultural Trust, will preside.

MRS. MARY FISHENDEN, Fuel Research Board, " Domestic Heating."

PROFESSOR J. C. DRUMMOND, D.Sc., F.I.C., Professor of Bio-Chemistry, University College, London, " Modern Views of Vitamins."

SIR ALFRED EWING, K.C.B., LL.D., D.Sc., F.R.S., Principal of the University of Edinburgh. (William Sturgeon Lecture, under the Dr. Mann Trust.)

PERCY DUNSHEATH, O.B.E., M.A., B.Sc., M.I.E.E., " Science in the Cable Industry."

JAMES PATERSON (of Messrs. Carter Paterson & Co., Ltd.), " Horse Traction and Motor Traction."

COLONEL W. M. COLDSTREAM, R.E., C.I.E., " Indian Maps and Surveys."

LADY CHATTERJEE, " Women and Children in Indian Industries."

HERBERT BAKER, A.R.A., F.R.I.B.A., " The New Delhi."

SIR RICHARD REDMAYNE, K.C.B., M.I.M.E., F.G.S., " The Work of the Imperial Institute." (Joint Meeting of Indian and Dominions and Colonies Sections.)

SIR MICHAEL F. O'DWYER, G.C.I.E., K.C.S.I., " Religions and Races in the Punjab." (Sir George Birdwood Memorial Lecture.)

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

January 22nd, February 19th, March 19th, April 16th, May 14th.

DOMINIONS AND COLONIES SECTION.

Thursday afternoons, at 4.30 o'clock.

February 4th, March 4th, May 6th.

CANTOR LECTURES.

Monday evenings, at 8 o'clock.

R. LESSING, Ph.D., F.C.S., M.I.Chem.E., "Coal Ash and Clean Coal." Three Lectures. November 23, 30, and December 7.

H. P. SHAPLAND, A.R.I.B.A., late Editor of the *Cabinetmaker*, "Ornament in Furniture." Three Lectures. January 18, 25 and February 1.

G. W. C. KAYE, O.B.E., D.Sc., Superintendent, Physics Department, National Physical Laboratory, "The Production and Measurement of High Vacua." Three Lectures. February 15, 22, and March 1.

W. F. HIGGINS, National Physical Laboratoy, "Thermometry." Two Lectures.

CHARLES REED PEERS, C.B.E., M.A., Director S.A., Chief Inspector of Ancient Monuments, H.M. Office of Works, "Ornament in Britain." Three Lectures. April 19, 26, and May 3.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, NOVEMBER 9..Geographical Society, 135, New Bond Street, W. 8.30 p.m. Dr. Knud Rasmussen, "From Greenland to the Pacific."

Surveyors' Institution, 12, Great George Street, S.W. 8 p.m. Mr. J. D. Wallis, Presidential Address.

Electrical Engineers, Institution of (Informal Meeting), Savoy Place, Victoria Embankment, W.C. 7 p.m. Mr. E. S. Ritter, "Modern Developments of Telephone Cables."

(N.E. Centre), Armstrong College, Newcastle-on-Tyne. 7 p.m. Mr. P. Dunsheath, "Dielectric Problems in High Voltage Cables."

Metals, Institute of (Scottish Section), 39, Elmbank Crescent, Glasgow. 7.30 p.m. Dr. J. A. Cranston, "The Binding Forces between Atoms."

Mechanical Engineers, Institution of, Storey's Gate, S.W. 6 p.m. Mr. E. B. Ball, "Some Engineering Features in connexion with Irrigation in South Africa."

Automobile Engineers, Institution of, at Chamber of Commerce, Birmingham. 7 p.m. Captain R. K. Hubbard, "The Requirements of the Military Motor Vehicle."

Brewing, Institute of, at Engineers' Club, 39, Coventry Street, W. 7.30 p.m. Mr. James Auld, "Raising Beer by Air Pressure."

East India Association, Caxton Hall, Westminster, S.W. 3.30 p.m. Mr. R. K. Sorabji, "The Warp and the Woof of the Fabric of Indian Life."

University of London, King's College, Strand, W.C. 5.20 p.m. Baron A. F. Meyendorff, "The Russian Church, Past and Present." (Lecture II.)

5.30 p.m. Rev. C. F. Rogers, "Ecclesiastical Music."

5.30 p.m. (Swiney Lecture.) Dr. W. T. Gordon, "Geology and Civilisation." (Lecture I.)

6 p.m. H. W. Steed, "Central Europe and the War." (Lecture I.)

At University College, Gower Street, W.C. 5.30 p.m. Professor E. Vermeil, "French Democracy and German Democracy." (In French.)

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Dr. O. Vocadlo, "From Bohemia to Czechoslovakia." (Lecture I.)

TUESDAY, NOVEMBER 10..Marine Engineers, Institute of, 85, The Minories, E. 6.30 p.m. Mr. E. F. Spanner, "Construction of Ships: a Proposed Method of Minimising Risks due to Collision."

Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 5.30 p.m. Ing. Leo Steinschneider, "The Principles of the High Vacuum Distillation of Mineral Oils"; Dr. W. R. Ormandy and Mr. E. C. Craven, "The Determination of Unsaturateds in Petroleum Spirit" and "The Determination of Molecular Weight of Petrol."

Automobile Engineers, Institution of, at Broadgate Café, Coventry, 7.30 p.m. Captain R. K. Hubbard, "The Requirements of the Military Motor Vehicle."

Anthropological Institute 52, Upper Bedford Place, W.C. 8.15 p.m. Mr. J. P. T. Burchell, "The Shell Mound Industry of Denmark as represented at Lower Halstow, Kent."

Electrical Engineers, Institution of (N. Midland Centre), Hotel Metropole, King Street, Leeds. 7 p.m. Mr. S. Derwen Jones, Chairman's Address.

(Scottish Centre), Technical College, Glasgow. 7.30 p.m. Dr. M. Maclean, Chairman's Address.

Aeronautical Engineers, Institution of, 39, Victoria Street, S.W. 6.30 p.m. "Practical Flying."

University of London, University College, Gower Street, W.C. 5.30 p.m. Lieut.-Col. E. F. Strange, "Far Eastern Art."

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Sir Bernard Pares, "History of Russia before Peter the Great." (Lecture V.)

At King's College, Strand, W.C. 5.30 p.m. Miss Hilda D. Oakley, "The Philosophy of Aristotle." (Lecture II.)

WEDNESDAY, NOVEMBER 11..Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. (Informal Meeting.) Sir Owen Williams, "The Relative Economy of Different Classes of Concrete for Reinforced Concrete Work."

Structural Engineers, Institution of (Lancashire and Cheshire Branch), Dr. E. S. Andrews, "A Critical Study of Regulations Governing the Design of Steel Framed Buildings."

Electrical Engineers, Institution of, The University, Birmingham. 7 p.m. Mr. W. R. Barclay, "The Development of Alloys of Nickel and Chromium for High Temperature Work and Electrical Resistance Heating."

Royal Academy of Arts, Burlington House, Piccadilly, W. 5 p.m. Dr. A. P. Laurie, "The Theory of Colour and its Application to Painting." (Lecture I.)

University of London, University College, Gower Street, W.C. 3 p.m. Prof. E. Gardner, "The Purgatorio." (Lecture IV.)

5.30 p.m. Prof. P. Geyl, "Dutch Colonial Policy since 1816." (Lecture II.)

5.30 p.m. Prof. G. Elliot Smith, "The Evolution of Man."

5.30 p.m. Prof. J. G. Robertson, "Swedish Literature in the Eighteenth Century."

5.30 p.m. Dr. E. A. Baker, "Methods of Reading."

(At the School of Oriental Studies, Finsbury Circus, E.C.) 5 p.m. Prof. H. H. Dadwell, "The Relation of Civil and Military Powers at Madras in the 18th Century."

At King's College, Strand, W.C. 5.30 p.m. M Paul Fort, "Paris Sentimental." (in French).

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. N. B. Jopson, "Early Slavonic History." (Lecture V.)

Meteorological Society, 49, Cromwell Road, S.W. 5 p.m. Dr. C. G. Abbot, "Measuring the Sun's Rays."

Thursday, November 12..Electrical Engineers, Institution of (Local Centre), University College, Dundee. 7.30 p.m. Mr. I. Sclar, "A Comparison of Electrical Wiring Installations and Analysis of their Costs." (Irish Centre), Trinity College, Dublin. 7.45 p.m. Mr. G. G. Sutcliffe, "Underground Telephone Construction."

Mechanical Engineers, Institution of (South Wales Branch), at the South Wales Institute of Engineers, Cardiff. 6 p.m. Eng.-Com. W. H. Reynolds, Chairman's Address.

Royal Society, Burlington House, Piccadilly, W. 4.30 p.m

Metals, Institute of, at the Royal School of Mines, South Kensington, S.W. 7.30 p.m. Dr. Hutton and Dr. Hudson, "Science and Industry: Some Impressions from the Early Experiences of the British Non-Ferrous Metals Association."

London County Council, at the Geffrye Museum, Kingsland Road, E. 7.30 p.m. Mr. A. L. Howard, "Furniture Timber of India Burma."

Child Study Society, 90, Buckingham Palace Road, S.W. 6 p.m. Mr. M. Yearsley, "The Development of Speech in the Normal Child."

Central Asian Society, at the Royal United Service, Whitehall, S.W. 5 p.m. Lieut.-Col. W. G. Grey, "Recent Persian History."

Oil and Colour Chemists' Association, 8, St. Martin's Place, W.C. (1) Dr. Tripp, "Chevreul: the Chemist, the Philosopher, the Man." (2) Mr. E. F. Figg, "Exposure Tests on Water Line Paints."

Aeronautical Society, 7, Albemarle Street, W. 5.30 p.m. Mr. H. B. Howard, "Some Problems in Aeroplane Structural Design."

Royal Academy of Arts, Burlington House, Piccadilly, W. 4 p.m. Dr. A. P. Laurie, "Early Methods of Oil Painting."

Optical Society, at The Imperial College of Science and Technology, South Kensington, S.W. 7.30 p.m. Mr. S. A. Emerson, "Some recent Improvements in Modern Ophthalmic Lenses." Mr. W. Swaine, "Relation of Visual Acuity and Accommodation to Ametropia." Mr. E. F. Fincham, "Irregular Astigmatism of the Eye-Effect of Size of Pupil." Mr. H. H. Emsley, "Irregular Astigmatism of the Eye-Effect of Correcting Lenses."

Historical Society, 22, Russell Square, W.C. 5 p.m. Miss L. M. Penson, "The Making of a Crown Colony--British Guiana, 1803-1833."

University of London, University College, Gower Street, W.C. 5.30 p.m. Major-General Sir George Aston, "The Study of War."

5.30 p.m. Dr. Camillo Pellizzi, "Idealisti Sensisti sulla fine del Settecento." (In Italian.)

5.15 p.m. Prof. de Montmorency, "Comparative Law." (Lecture IV.)

At King's College, Strand, W.C. 5.15 p.m. Rev. N. Sykes, "The Social and Political Ideas of some Great Thinkers of the Sixteenth and Seventeenth Centuries—Lecture IV.: Richard Hooker."

5.30 p.m. Mr. E. Prestage, "The Role of Diplomacy in the Struggle between the Portuguese and Dutch for Brazil (1641-1661)."

At King's College, Strand, W.C. 5.30 p.m. Sir Arthur Newsholme, "The Community and Social Hygiene."

University of London, at Bedford College, Regent's Park, N.W. 5.15 p.m. C. Collins Baker, "Italian Painting: its Place in Art."

At Birkbeck College, Fetter Lane, E.C. 5.30 p.m. Sir Henry Slesser, "Trade Union Law." (Lecture I.)

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Prince D. S. Mirsky, "Russian Literature since Chekhov." (Lecture VI.)

At King's College, Strand, W.C. 5 p.m. Dr. C. Da Fano, "Histology of Nerve Tissues and Paths of Conduction in the Central Nervous System." (Lecture VI.)

Friday, November 13..London Society, at the Royal Society of Arts, John Street, Adelphi, W.C. 5 p.m. Sir Frank Baines, "The History and Preservation of Westminster Hall."

Engineering Inspection, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 7.30 p.m. Mr. W. H. Hatfield, "Modern Developments in Steels Resistant to Corrosion."

Mechanical Engineers, Institution of (Yorkshire Branch) at the Philosophical Hall, Park Row, Leeds. 7.30 p.m. Sir Henry Fowler, Repetition of the Thomas Hawksley Lecture by Sir John Aspinall, "Some Railway Notes, Old and New."

Metals, Institute of (Local Section), University College, Singleton Park, Swansea. 7.15 p.m. Mr. L. B. Pfeil, "Effect of Crystal Size on the Mechanical Properties of Metals."

Astronomical Society, Burlington House, Piccadilly, W. 5 p.m.

Metals, Institute of (Local Section), the University, St. George's Square, Sheffield. 7.30 p.m. S. Field, "Recent Advances in Electro-Deposition."

Royal Academy of Arts, Burlington House, Piccadilly, W. 4 p.m. Dr. A. P. Laurie, "Painting Media: Oils, Varnishes and Tempera."

University of London, University College, Gower Street, W.C. 8 p.m. Prof. G. D. Hicks, "Contemporary English Philosophy." (Lecture II.)

5.30 p.m. Prof. E. Vermeil, "Intellectual Relations between France and Germany." (In French.)

At King's College, Strand, W.C. (Swiney Lecture.) 5.30 p.m. Dr. W. T. Gordon, "Geology and Civilisation." (Lecture II.)

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Dr. R. W. Seton-Watson, "Serbia and the Jugo Slavs." (Lecture V.)

Physical Society, Imperial College of Science, South Kensington, S.W. 5 p.m. (1) Mr. T. G. Hodgkinson "Valve Maintained Tuning Forks without Condensers." (2) Messrs. R. G. Edwards and B. Worswick, "The Viscosity of Ammonia Gas." (3) Dr. C. Chree, "The Times of Sudden Commencements (S.C.'s) of Magnetic Storms: Observations and Theory." Demonstration of the Kinetic Properties of a Gas Jet by Dr. J. S. G. Thomas.

Malacological Society, Burlington House, Piccadilly W. 6 p.m. (1) Mr. W. A. Lindholm, "On a Neglected Work Containing Typifications of Molluscan and Brachiopodan Genera." (2) Mr. Edwin Ashby, "The Acanthoid Chitons of New Zealand with Descriptions and Figures, including several New Species and Photographs of previously unfigured Types." (3) Mr. A. W. B. Powell, "Description of two new Gastropods from Whangaroa, New Zealand." (4) Messrs. A. S. Kennard and B.B. Woodward, "Nomenclatorial Notes Relative to British Non-Marine Mollusca.—IV.' (5) Rev. E. G. Alderson, "The *Ampullaria swainsoni* of Philippi, Hanley and Reeve." Exhibits: Illustrations and photographs, taken from the type specimen in the Senckenberg Museum, of *Palaina mirabilis* Mlldff. By Mr. B. B. Woodward. Specimens of Shells and Radulæ illustrating a new Molluscan Family and Genera. By Mr. J. R. Le B. Tomlin, and Lt.-Col. A. J. Peile.

Saturday, November 14..Transport Institute (N. Eastern Section), Town Hall, Newcastle-on-Tyne. 3 p.m. Mr. C. J. Allen, "British Main Line Passenger Train Services, their Characteristics and Possibilities.'

London County Council, at the Horniman Museum, Forest Hill, S.E. 3.30 p.m. Mr. R. A. Smith, "Aspects of Roman London." (Lecture II.)

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FRIDAY NOVEMBER, 13th, 1925.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

WEDNESDAY, NOVEMBER 11th, at 8 p.m. (Ordinary Meeting.) INGLESON C. GOODISON, "The Furniture of Hampton Court and other Royal Palaces." H. AVRAY TIPPING, F.S.A., will preside.

The paper will be fully illustrated with lantern slides.

FIRST ORDINARY MEETING.

WEDNESDAY, NOVEMBER 4th, 1925. SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., LL.D., F.R.S., Chairman of the Council, in the chair.

The following candidates were proposed for election as Fellows of the Society :—

Allely, William S., Yardley, Birmingham.
Bancroft, Joseph, Wilmington, Delaware, U.S.A.
Bannister, Horace William, Liverpool.
Bell, A. B., Glasgow.
Biswas, J. K., Cuttack, Orissa, India.
Bowen, Miss Anna C., Batavia, New York, U.S.A.
Chatterjee, Baidya Nath, M.A., Calcutta, India.
Chettiar, S. RM. Chockalingam, Trichinopoly, India.
Cooper, John Ashton Jeffree, Ilford, Essex.
Croucher, Thomas G., Loughborough.
Cumberworth, The Revd. Charles John, D.Litt., B.D., Halifax.
Ditson, Jesse, Littleton, Colorado, U.S.A.
Elliott, Arthur F., Prescot, Lancs.
Ellis, George Reginald, Hitchin, Herts.
Emra, Frederic Harcourt, Ottawa, Canada.
Evans, Ernest John, Calcutta, India.
Farmer, Charles, Nottingham.
Fortune, Allan, Keighley, Yorks.
Frobisher, Charles, Prescot, Lancs.

Griffith, Wellington John, Junr., London.
Gurnett, Clyde Upton Brougham, Sydney, Australia.
Hasan, Syed Amir, Benares, U.P., India.
Hessling, Frederick, Bombay, India.
Hickton, E. B., Crewe.
Joshi, G. S., M.A., LL.B., Bhopal, Central India.
Kriplani, Choith R., London.
Lane, Reginald Willington, Loughton, Essex.
McDonald, Colonel George Frederic Handel, O.B.E., T.D., Hornchurch, Essex.
Mordey, William, Llantarnam, Newport, Mon.
Mukherjee, Dr. H. N., Calcutta, India.
Munn, W. Faitoute, East Orange, N.J., U.S.A.
Nathan, S. V., B.A., London.
Owen, Frank, East Grinstead, Sussex.
Parkhurst, J. Wyndham, Crawley, Sussex.
Picado, Ramon M., Costa Rica, Central America.
Pocock, Hugh Shellshear, London.
Price, Norman I., Sydney, Australia.
Printer, D. H., Bombay, India.
Rangin, Kandhar Singh, B.A., Jullundur, Punjab, India.
Roberts, Edward William, London.
Rumney, Howard, London.
Sastry, Kuppa Subbanna, Ellore, Madras, India.
Siedle, Frederick Julian, Colombo, Ceylon.
Stedham, Miss Nellie, Southsea, Hants.
Sylvain, Charles E. B., Rio de Janeiro, Brazil.
Tatham-Thompson, Douglas Argyll, Guildford, Surrey.
Tidwell, Professor J. B., M.A., D.D., LL.D., Waco, Texas, U.S.A.
Townsend, Walter, Hull, Yorks.
Vallet, Cyril Edward Franklin, Addlestone, Surrey.
Vardy, Mrs. Lucia, Whitwood, Normanton.
Warwick, George Withrow, Algeciras, Spain.
Wei, E. Fah, Peking, China.
White, Frank Byron, Wokingham, Berks.
Wisdom, Brig.-General Evan Alex. C.B., C.M.G., D.S.O., British New Guinea.
Zutshi, M. N., B.A., Pilane, Jaipur, India.

The Chairman's address on "The Organisation of Scientific Research throughout the Empire" will be published in the next number of the *Journal.*

DOMINIONS AND COLONIES SECTION.

A meeting of the Dominions and Colonies Section Committee was held on Tuesday, October 27th. Present:—Sir Humphrey Leggett, R.E., D.S.O. (in the chair); Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., LL.D., F.R.S. (Chairman of the Council); Sir Charles H. Bedford, LL.D., D.Sc.; Mr. Byron Brenan, C.M.G.; Hon. Sir John Cockburn, K.C.M.G.; Mr. Edward Dent, M.A.; Colonel W. H. Franklin, C.B.E., D.S.O.; Major H. Blake Taylor, C.B.E.; and Mr. George Wilson, C.B., with Mr. G. K. Menzies, M.A. (Secretary of the Society).

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "Radiological Research—A History," by V. E. Pullin, Director, Radiological Research Department, Woolwich, have been reprinted from the *Journal*, and the pamphlet (price 2s.) can be obtained from the Secretary, Royal Society of Arts, John Street, Adelphi, W.C.

A full list of the lectures which have been published separately and are still on sale, can also be obtained on application.

ORCHID CULTIVATION.*

By Sir Jeremiah Colman, Bt., M.A., J.P., D.L., V.M.H.,
Chairman R.H.S. Orchid Committee.

Whilst disclaiming the expert knowledge of a "grower," yet, as a looker-on for upwards of thirty-five years, dating back to a time when Sir Trevor Lawrence specialized in species and rare genera and when the late Baron Schröder acquired priceless gems of the Orchid world, I may have some justification for expressing views on cultivation of Orchids. I have been an importer of plants in small quantity, especially in directions where the trade finds it unremunerative, and have raised in my collection more than one thousand distinct crosses; which, presuming only an average of twenty or twenty-five to a family, represents twenty or twenty-five thousand hybrids brought to maturity, many of them very difficult subjects to deal with, as crosses have been made with a view to distinct variation and for experiment. I have raised hybrids, one parent of which is accustomed to be wet and cool all the year round, while the other is a native of a hot and "dry" country, where its thirst is satisfied by an excessive bout of drinking for a few weeks in the year. I doubt whether the offspring knows what its requirements may be.

I suppose no collection, when species and hybrids are taken together, has greater variety than mine at Gatton Park.

Orchid-growing is no exception to the rule that there is a catch somewhere. However carefully expert methods may be observed, success will not follow without the human touch, and the constant and intelligent observation which alone leads to success. The talented grower will require that indescribable gift known as instinct. The owner of a collection, as well as the grower, should instinctively know on entering his houses whether temperatures are correct, and prevailing atmospheric conditions, particularly in respect to humidity and purity, are suited to the needs of the plants; and their surroundings congenial or the reverse. The qualifications required are not dissimilar from those of a nurse watching a patient: any change in the condition should be promptly noted and reported for special attention.

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* Abstracted and condensed from an article published in the *Journal* of the Royal Horticultural Society.

No hard-and-fast lines can be laid down. The problem is a very difficult one, especially in the case of the many Orchids which require resting periods, since in their case it is natural for them to appear " off colour " during such periods, and it would be fatal to mistake this normal condition for ill-health.

Unless some particular grower has the secret, no " food " has yet been discovered which can be used in growing a general collection of Orchids without serious prejudice to the plants. Experiments have been made by scientists, but the results were disastrous ; and therefore " feeding " is not to be recommended, except for the purposes of experiment, and in the case of a few genera which are the better for it. But I have a conviction that some " food " should be found which will prove advantageous, and that the day will come when chemists will supply us with a non-injurious prescription. It appears to me that the logic of the situation clearly points to this. Orchids, just as is the case with other plants, deprive the compost in which they are growing of certain constituents which are essential to their well-being. In the case of other plants these can be restored by suitable fertilizers. It is recognized that Orchids have similar requirements, but the only acknowledged way of meeting these requirements is to give them fresh compost, either by a top dressing or repotting, a process often disturbing to the seedling or plant. Hence I am sanguine enough to believe that a day will come when an appropriate " food " will be found which can be given to Orchids in a way similar to that in which other plants receive stimulants.

One thing is certain, plants must have no " coddling." A plant can be killed with kindness and attention, and it may be for its good to be forgotten altogether for a period. In my greenhouses, as a last resort in the case of Odontoglossums, the bulbs are taken away from the pot and suspended with bass to the rafters in the potting shed and there left to work out their own salvation. A considerable proportion of such plants ultimately make a growth and are re-established.

Those who are forming a collection, or thinking of growing a few plants only, would be well advised to consider carefully the facilities which they may have for growing Orchids, and the special abilities of their gardener, so as to make a selection likely to grow under prevailing surroundings, as it is inviting disappointment, and is not fair to a gardener, to attempt the impossible. Gardeners are human and Orchids are capricious ; and a gardener, even an expert grower, may succeed well with one family and fail altogether with another ; selection should therefore be made with due regard to his powers. Few realize when inspecting an important group of Orchids how many families are represented, each requiring widely different treatment and conditions of culture. In fact, at our great shows, a group of Orchids may represent a diversity of requirements approaching those necessary for the production of the rest of the plants in the show. Many lovers of horticulture attend these shows and make a selection from the various groups. In making a selection of, say, begonias or sweet peas, the question of culture need not be considered, because each will flourish under treatment required for the class. Not so when one comes to the selection from an Orchid group. I have heard of purchasers selecting half a dozen from a group, each one of which required placing in a different house—with perhaps two greenhouses at the most for their unfortunate gardener to attempt to grow them in; nothing but disaster and disappointment can follow. Whereas, if they start by satisfying themselves as to what conditions prevail in their greenhouses, the attendant in charge of the group could at once tell them what they might reasonably attempt to grow. There is not the least difficulty in making a selection from some of the most beautiful Orchids in cultivation of plants which can be quite easily grown, and which are quite reasonable in price.

Another point worth bearing in mind is that if a specimen plant is purchased in perfect health no improvement can be looked for. It is almost inevitable that it will go back rather than forward. Beginners should on no account purchase plants out of health. But, on the other hand, if the plant is in a condition which gives room for improvement, the owner is much more likely to find satisfaction in the results than if he buys a plant in perfect health, heavily flowered, which in all probability, even if it remained in its old surroundings, would in twelve months' time have deteriorated.

The attempt to grow the difficult subjects is much better left to a later stage when experience has been gained.

Of easy plants to grow, on which a start might be made, are Cymbidiums, amongst the most beautiful of Orchids, with graceful sprays of flowers lasting in perfection for many weeks, and which may even be grown in a house with a northern aspect; Cypripediums, which have the gift of withstanding fog and smoke, and the flower of which is also long lasting in perfection; and the beautiful and cool-growing Odontoglossums.

Those contemplating growing Orchids should not be put off by the common fallacy that they are difficult to grow and expensive to acquire. If suitable choice is made, they can be purchased so cheaply that the cost is not worth consideration, and many of the most beautiful are as easily grown as any greenhouse plant.

I have so far avoided technicalities of cultivation which are readily available, but now that I turn to the advanced, or scientific, side of Orchid culture, no such restriction is called for, growers having had but limited opportunity for initiation into its intricacies, or of realizing how intensely fascinating it may become, and how vast are the possibilities open for future research and experiment. There may be included in scientific methods of Orchid culture, hybridization, pure culture, artificial and experimental lighting, electric stimulation, and—may I add?—feeding.

On what slender threads hang our interests in life! When it occurred to a genius to make the rather obvious experiment of transferring the tiny pollen mass from one flower and placing it on the stigma of another, who anticipated that it would lead to results destined to revolutionize orchidology?—that it sounded the death-knell of the travelling collector: that Orchid-collecting, as known in the past, would cease to be a profitable proposition, and that importing houses would as a consequence be compelled to discontinue their enterprise in this direction: that natural hybrids which were changing hands at fabulous prices would be surpassed by home-produced ones manufactured in their thousands by the instrumentality of mere man, and be offered at prices within the reach of every grower: that the fine and once treasured species which adorned our houses were doomed gradually to disappear therefrom: that groups would be set up containing no single specimen of a pure species, and that the colour of one and shape and substance of another would be so combined as to produce a result beyond imagination: that learned men would spend their time in examining and discussing the functions of the fungi essential to the completion of the germination of Orchid seeds: and that in place of pots would appear, in some greenhouses, glass tubes and flasks charged with mysterious solutions, on which myriads of Orchid seedlings would be seen growing. All this has been accomplished within a comparatively short period. Whither may we not be led?

Hybridization is not confined to our country alone. Rapid strides are being made on the Continent, where climatic conditions are highly favourable. America is taking the subject up seriously, and in far-distant Japan attention is being given to it. In the latter country, Orchids are favoured subjects in the Imperial and other gardens; and when we find so enterprising a nobleman as Prince Shimadzu evidencing a keen interest in this hobby, we may be well assured that, with the æsthetic taste and perseverance which prevail in everything which the Japanese take up, many notable successes will be achieved. Climatic conditions there are especially favourable to some genera, and they have already raised bi-generic and other hybrids which have proved difficult or impossible subjects here.

Thus when a beginner realizes what has been accomplished, and remembers that democratic theories do not hold good in the case of Orchids, in the raising of which heredity counts for something and experience shows that you must have noble parents if you would raise noble offspring, he may well pause before following well-trodden routes.

There are, however, untrodden ways open to him which may bring fame. Should he possess a unique plant, he should on no account fail to use it for hybridizing purposes, and may have reasonable hopes of producing unique results.

The remarkable results arising from the use of *Miltonia vexillaria* × 'Memoria G. D. Owen' as a parent is a case in point. When the stock of this plant realized well over four figures on the occasion of the dispersal of the late Sir Frederick Wigan's fine collection, many thought purchasers were indulging in wild speculation; but the results justified their expectation, and we have been given the beautiful new strain in which the claret-coloured butterfly mask is the feature. This genus has been further improved out of all knowledge by the introduction of varieties the sepals and petals of which are of a rich and deep-coloured rose or claret.

Experiments can with advantage be attempted which, not being paying propositions, are not worth the consideration of the trade. For instance, I have at Gatton raised a strain of Cattleyas and Laeliocattleyas which have acquired a reputation and have become familiarly known as 'Gatton Blues.' Neither in size, nor in substance, nor in colour will the expert look upon them with favour: they fail to meet the arbitrary standard which the orchidist has set up; but when they are in bloom visitors to my houses are lost in admiration, and if expert Orchid fanciers view them with contempt, I console myself with the feeling that they are at least things of beauty and my very own! I am hoping against hope that some day I may produce a large-flowered Brassocattleya of 'Gatton Blue,' and then there will be a very different tale to tell! Similar results can be obtained by others with advantage to horticulture, even if not favoured by the Orchid world.

Many growers find hybrids difficult subjects to raise. The absence of the essential fungi may prove fatal in the initial stage, otherwise no real difficulty presents itself. All young lives require more constant and watchful care than older ones, but, given attention, they will grow as freely or more freely than an older generation.

There are many enemies—creeping, flying, and floating—from which they must be protected, and one of these may devour at a meal a whole pot of seedlings; whereas if it visits an established plant its hunger would be satisfied by a portion of the flower or stalk, and the mischief to the seedlings is naturally proportionately greater than to the older plants.

One of the most mischievous pests is a provoking, insignificant little insect, by name Collembola, or spring-tail, the larvæ of which hollow out the little green seed globules, leaving an empty shell. I have failed to discover any remedy for its depredations. Many injurious insects make themselves scarce for a time after fumigation, or can be kept under control by the simple method of sponging with a disinfectant; whilst some are innocent enough to allow themselves to be trapped in a hollowed-out potato, or other deceptive retreat. Others are as cunning and illusive as a wild animal, and might tax the skill and patience of the big-game hunter to discover and track down. But, after all, we may console ourselves with the thought that a goodly number of seedlings survive.

The mysteries of the essential fungus are important enough to have a paragraph to themselves. Scientists are not agreed as to the precise function which the fungus performs, or whether the fungus is in all cases actually necessary, or whether a substitute may not suffice. But it is generally recognized that the seeds of certain species, e.g., Odontoglossums, will not germinate without the aid of the fungus essential to the species or some substitute. Seeds of Cattleyas, etc., can be raised apart from the parent plant, apparently without fungus, although some think this not free from doubt. Some houses seem to be permeated with fungus spores, and wherever the seed is sown successful germination follows. In others the fungus would seem to be altogether absent. At Gatton, after years of sowing Odontoglossum seeds without result, I was on the point of giving up the attempt as hopeless, when young plants made their appearance, and ever since no difficulty has arisen—although an expert has blithely told me that some day I shall find the fungus will vanish just as mysteriously as it arrived! The fungus may be found in the centre of the young roots which have entered the compost, rarely, if ever, in the aerial roots.

When we turn from hybridization as commonly attempted to the much more scientific and involved methods known as "pure culture," we find growers are not in agreement as to the measure of its advantages; some, whilst acknowledging that plants make more rapid progress in the early stages, think that those grown under normal methods catch them up in the long run, and are in more robust health. But in Orchid-raising a speedy and a certain start is half the battle, to which has to be added the very distinct advantage, especially in the case of pods containing only a few fertile seeds, that such good seeds as there are will be given the maximum chance of germination. The mortality under ordinary methods is large, from various causes, including insect pests; and if a few seeds only germinate, they will, when making their start under ordinary methods, be at the mercy of any such enemy with an insatiable appetite. It is a well-recognized law of Nature that the most complicated crosses and those between the most refined parents produce the minimum of fertile seeds. Cases have come under my observation where a pod has apparently contained less than half a score of fertile seeds, although it has been estimated that the contents of a single pod may reach half a million seeds. It cannot, I think, be open to question that, in the case quoted, seeds have a better chance under pure culture methods than under ordinary methods. The result of another experiment in my houses was interesting and instructive, and shows that uncertainties exist under pure culture also. A sowing was made in a tube in which fungus had been cultivated on medium. A portion of the seed fell on the glass above the medium and remained dormant; a second portion fell on the edge of the medium; germination apparently started, but the seed died, presumably as a consequence of receiving insufficient food. Yet a third fell in the centre and produced a green mass, presumably gorged to excess; whilst a fourth fell still lower, where the fungus growth appeared less strong, and this brought forth fine young plants. The result will suggest the Parable of the Sower. No doubt, with greater experience, more even results should be assured; and one can but expect to find it necessary to feel one's way at the outset at every turn. As pure culture methods become public property and are better understood they will doubtless be much more largely adopted. In practice they are at present beset with difficulties; they require the unusual combination of laboratory and garden methods to secure success. Strictly aseptic conditions must prevail. The removal of a stopper from a container, if only for a few seconds, will likely enough result in the introduction of mould spores. The mould will rapidly cultivate and inevitably choke the fungus and prove fatal.

In respect to the effect of artificial light, the use of sunlight by refraction and electric treatment, few experiments have as yet been made upon Orchids, and to a limited extent only upon plants generally. This leaves a wide and virgin field open, which might be very profitably explored by anyone with a knowledge of electricity and optics. Experiments in the nature of the application of artificial light go to suggest that in some cases the flowering period is advanced and in others retarded—more frequently the latter. No doubt results depend largely upon whether the sunlight which the plants are receiving is greater or less than they have been accustomed to in their native country or which they may require; but as artificial light has an effect not injurious, in some cases at least, upon plant life, one would be sanguine that advantageous results may follow experiments which might be extended to refracted light from the sun's rays. There has been a suggestion that rays from the moon have a special influence, and that in certain phases thereof plants make more rapid growth. This may sound fantastic, but is based on observation. Anyone with scientific knowledge and opportunity of examining the subject experimentally may hope to become a national benefactor. The value of the ultra-violet rays in relation to the health of humanity is now recognized; and if data can be found in respect to the results of using artificial light and radiation upon Orchids, inferences may be drawn with far-reaching effects. Orchids suggest themselves as very ready subjects on which to experiment, as in their early stages, at any rate, they require so little space, and will so speedily respond and show the results of treatment.

Skilful and scientific methods have accomplished much. The position occupied by the aristocrat of floriculture is supreme and unapproachable. No flower approaches an Orchid for lasting qualities. In 1923 I dispatched plants in flower from my gardens at Gatton: they crossed the Atlantic, and arrived fresh enough to be set up in a group at the American International Show held at Boston, U.S.A. But, however much has been accomplished, the possibilities of the future are great and inviting. They await the interest and attention of those capable of undertaking and following up scientific experiments, which cannot fail to be of value remote from the Orchid world. Who, I wonder, is destined to make history and win fame?

CONTRIBUTIONS TO THE READING ROOM.

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Times of India (Overland Weekly Edition)

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

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MONDAY, NOVEMBER 16..Royal Academy of Arts, Burlington House Piccadilly, W. 4 p.m. Dr. A. P. Laurie, "Modern Pigments: their proper Selection and Use."

Electrical Engineers, Institution of, at the University, Liverpool. 7 p.m. "The Engineer: His Due and His Duty in Life."

Geographical Society, Lowther Lodge, Kensington Gore, S.W. 5 p.m. Mr. Francis Rodd, "The Origin of the Tuaregs."

Transport, Institute of, at Queen's Hotel, Birmingham. 6 p.m. Mr. H. Koaze, "Relations between State and Railways in Japan."

Faraday Society, Burlington House, Piccadilly, W. 8 p.m. Mr. E. D. Campbell, "A Chemical Theory of Remanent Magnetism"; Messrs. J. R. Partington and N. L. Anfilogoff, "An Improved Form of Electric Vacuum Furnace"; Messrs. J. R. H. Coutts and E. M. Crowther, "A Source of Error in the Mechanical Analysis of Sediments by Continuous Weighing"; Mr. Donovan Werner, "A Simple Method of Obtaining the Size Distribution of Particles in Soils and Precipitates"; Mr. J. A. V. Butler, "Co-ordination and Co-valence"; Messrs. F. G. Tryhorn and W. F. Wyatt, "Adsorption by Charcoal from Alcohol-Benzene and Acetone-Benzene Mixtures"; Mr. F. L. Usher, "The Nature of the Interfacial Layer between an Aqueous and a non-Aqueous Phase."

University of London, at Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Dr. Otakar Vocadlo, "From Bohemia to Czechoslovakia." Lecture II
At King's College, Strand, W.C. 5.30 p.m. Dr. W. I. Gordon, "Geology and Civilisation." Swiney Lecture III.; Rev. C. F. Rogers, "Ecclesiastical Music." Lecture IV.; Baron A. F. Meyendorff, "The Russian Church, Past and Present." Lecture III.

TUESDAY, NOVEMBER 17..Royal Academy of Arts, Burlington House, Piccadilly, W. 4 p.m. Dr. A. P. Laurie, "Methods of Wall Painting."

Anthropological Institute, 52, Upper Bedford Place, W.C. 8.15 p.m. Dr. E. H. Hunt, "Recent Work in Hyderabad Cairn Burials."

Automobile Engineers, Institution of, at Engineering Club, Wolverhampton. 7.30 p.m. Captain R. K. Hubbard, "The Requirements of the Military Motor Vehicle."

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Prof. W. E. Dalby, "The Mechanical Properties of Steel."

Electrical Engineers, Institution of, at the Engineers' Club, Albert Square, Manchester. 7 p.m. Mr. P Dunsheath, "Dielectric Problems in High-Voltage Cables."

Electrical Engineers, Institution of, at Leicester. 6.45 p.m. Mr. J. A. Aiton, "Steam Pipes for extra high Pressure and Temperature."

Transport, Institute of, at Institution of Electrical Engineers, Savoy Place, W.C. 5.30 p.m. Mr. Cecil J. Allen, "British Main Line Passenger Train Services—Their Characteristics and Possibilities."

University of London, at King's College, Strand, W.C. 5.30 p.m. Miss Hilda D. Oakeley, "The Philosophy of Aristotle." (Lecture III.)
At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m Sir Bernard Pares, "History of Russia before Peter the Great." (Lecture VI.)

Physiology, London College of, 8, Taviton Street, W.C. 8.15 p.m. Mr. H. J. Harper-Roberts, "Ringworm."

Wednesday, November 18..Statistical Society, at the Royal Society of Arts. 5.15 p.m. Prof. G. Udny Yule, "Why do we sometimes get nonsense-correlations before time series? A study in sampling and the nature of time series." (Presidential Address.)

Royal Academy of Arts, Burlington House, Piccadilly, W. 4 p.m. Dr. A. P. Laurie, "The Selection Stone for Building."

Chemistry, Institute of, 30, Russell Square, W.C. Annual General Meeting.

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Mr. Julius Kennard, Address to Students.

Electrical Engineers, Institution of, at Royal Victoria Hotel, Sheffield. 7.30 p.m.

Entomological Society, 41, Queènsgate, S.W. 8 p.m.

Meteorological Society, at 49, Cromwell Road, S.W. 5 p.m. Sir Gilbert Walker, "On Correlation Co. efficients: their calculation and use"; Miss C. O. Stevens, "Note on the Variations in Transparency of the Atmosphere observed by means of a projected telescopic image of the Sun"; Mr. N. L. Silvester, "Notes on the Behaviour of Certain Plants in relation to the Weather."

Royal United Service Institution, Whitehall, S.W. 3 p.m. Major-General Sir J. H. Davidson, "Imperial Defence and the Co-ordination of the Three Services."

University of London, at University College, Gower Street, W.C. 5.30 p.m. Prof. G. E. Smith, "Fossil Men and Apes."
At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Mr. N. B. Jopson, "Early Slavonic History." (Lecture VI.)
At King's College, Strand, W.C. 5.30 p.m. M. Paul Fort, "Les Temps Héroiques du Symbolisme: Le Théâtre d'Art et les Premiers Drames de Maurice Maeterlinck." (In French).

Thursday, November 19..Antiquaries, Society of, Burlington House, Piccadilly, W. 8.30 p.m.

Chemical Society, Burlington House, Piccadilly, W. 8 p.m. Messrs. E. C. C. Baly and R. W. Riding, "The Constitution of the Metallic Ozonides." Messrs. T. M. Lowry and I. J. Faulkner, "Studies of Dynamic Isomerism." Part XX. Amphoteric Solvents as Catalysts for the Mutarotation of the Sugars."; Messrs. T. M. Lowry and G. Owen, "Studies of Valency Part V. Absorption-spectra of Halogen and Sulphonic Derivatives of Camphor. Origin of the Ketonic Absorption-band."; Messrs. T. M. Lowry and R. R. Sass, "Studies of Valency. Part VI. General and Selective Absorption of Halogen-derivatives of Methane. The origin of general absorption"; Messrs. R. G. W. Norrish and G. G. Jones, "Studies of Valency. Part VII. Surface Polarity and the Reaction of Ethylene and Chlorine. The effect of the absorbed water layer."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. Mr. T. Carter, "The Engineer—His Due and his Duty in Life."

Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

Linnean Society, Burlington House, Piccadilly, W. 5 p.m.

London County Council, at the Geffrye Museum, Shoreditch, E. 7.30 p.m. Mr. Ernest Law, "Hampton Court."

Mining and Metallurgy, Institution of, at Burlington House, Piccadilly, W. 5.30 p.m.

Mechanical Engineers, Institution of, at Royal Technical College, Glasgow. 7.30 p.m. Further discussion on "Cast Iron for Diesel Engines." (Joint Meeting with Scottish Section of Association of British Foundrymen)
At Queen's Hotel, Birmingham, 6.30 p.m. Mr. H. W. Coultas, "Some Hydraulic Problems."
At the Engineers' Club, Albert Square, Manchester. 7.15 p.m. Col. E. Kitson Clark, "Archaeological Engineering."

Royal Society, Burlington House, Piccadilly, W. 4 p.m. Special General Meeting.

Tropical Medicine and Hygiene, Royal Society of, Endsleigh Gardens, Euston Road, N.W. 8.15 p.m. Laboratory Meeting. Demonstrations by Col. A. Alcock, Drs. A. Balfour, H. A. Baylis, Major K. K. Chatterji, Drs. A. Castellani, J. I. Duncan, Th. Joekes, Prof. R. T. Lieper, Drs. H. B. Newham, H. H. Scott, Lt.-Col. H. M. Perry, Drs. N. A. Dyce Sharp, Gordon Thomson, and C. M. Wenyer.

University of London, at Birkbeck College, Fetter Lane, E.C. 5.30 p.m. Sir Henry Slesser, "Trade Union Law." (Lecture II.)
At King's College, Strand, W.C. 5 p.m. Dr. C. Da Fano, "Histology of Nerve Tissues and Paths of Conduction in the Central Nervous System." (Lecture VII); 5.15 p.m. Miss H. M. Chew "King James I."
At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Prince D. S. Mirsky, "Russian Literature since Chekhov." (Lecture VII.)
At Bedford College, Regent's Park, N.W. 5.15 p.m. Sir Robert Watt, "Eighteenth Century Art."

Friday, November 20..Model Abattoir Society, at 1, Wimpole Street, W. 5.30 p.m. Dr. W. J. Howarth, "The Slaughtering of Animals for Human Consumption." (Benjamin Ward Richardson Memorial Lecture).

Medical Officers of Health, Society of, 1, Upper Montague Street, W.C. 5 p.m. Dr. H. P. Newsholme, "Measles—from the point of view of Public Health Administration;" Dr. J. F. Walker, "Measles—from the point of view of Private Practice" Dr. E. W. Goodall, "Measles—from the point of view of Fever Hospital Practice."

Société Internationale de Philologie Sciences et Beaux-Arts, 8, Taviton Street. W.C. 8.15 p.m. Dr. E. H. Griffin, "The Bond of Shylock."

Mechanical Engineers, Institution of, Storey's Gate, St. James's Park, S.W. 6 p.m. Mr. H. F. L. Orcutt, "Characteristics and Uses of Ground Gears."

University of London, at Westfield College, Hampstead, N.W. 5.15 p.m. Prof. E. de Selincourt, "The Art of Conversation."
At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Dr. R. W. Seton-Watson, "Serbia and the Jugo Slavs." (Lecture VI.)
At King's College, Strand, W.C. 5.30 p.m. Dr. W. T. Gordon, "Geology and Civilisation." (Swiney Lecture IV.)

Saturday, November 21..London County Council, at the Horniman Museum, Forest Hill, S.E. 3.30 p.m. Mr. G. C. Robson, "Animal Life in the Depths of the Sea."

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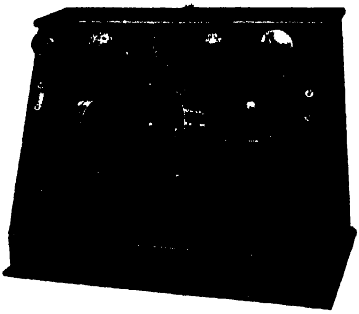

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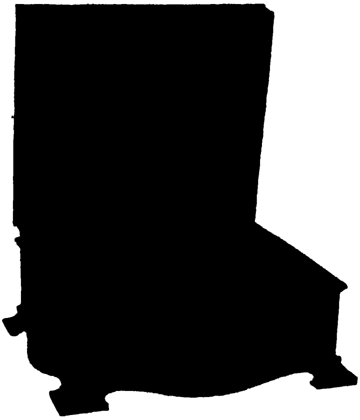

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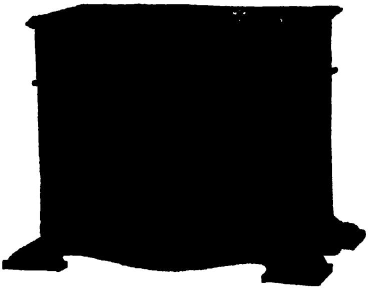

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THE RULE OF THE ROAD.

UNWRITTEN LAWS NOW WRITTEN.

The Road is one of the few places where the expert is more dangerous than the novice.

Practically all accidents on the road are avoidable. They are almost invariably due to one of two common human failings—carelessness and lack of consideration for other people. It is seldom lack of experience in drivers that travellers have to fear. The usual tendency of a novice is to be extra careful. To say that the novice is more likely to lose his head has nothing to do with it, because there ought to be no tight corners. A man has a perfect right to lose his head; it is the man who causes him to lose it that is to blame. Besides, no human head is a guaranteed fool-proof machine, therefore it is up to us not to expect too much from it.

There is more danger on the road from the expert and over-confident driver than from any other kind. Many of the worst road-hogs are, as a matter of fact, very clever drivers.

Now there are not many rules of the road that an ordinary intelligent man with the instincts of a gentleman cannot think out for himself, without assistance, and does not already act upon. But there are a number of points that few would think of. Also, there are many people who do not think of even simple things until they are told. For this reason a little book entitled " Road Wisdom " is very welcome. It is published by the proprietors of Pratt's Motor Spirit, 36, Queen Anne's Gate, S.W.1.

It consists of a number of short paragraphs dealing with road use and abuse in general, as well as the many dangers commonly met with in motoring. Originally, they formed part of a press campaign towards the betterment of motoring conditions generally and were published under the title of " Prattitudes of the road." This booklet is the answer to a number of requests for their reproduction.

Many of them, as has been said, are common sense cautions and appeals to courtesy and a fraternal outlook. Others are very valuable tips that few would think of—such as the new " off-side " rule of the A.A. (watch for and give way to traffic approaching from the right) and short articles on valve adjustment, electric light logic, gear-changing, the rights of the motorist, etc.

Each typical incident is illustrated with diagrams and drawings—the latter coloured and exceedingly well-drawn, and the booklet is a most attractive little production.

THE ROAD FUND.

There is every indication that strenuous opposition will be offered to the suggested diversion of the Road Fund from its original purpose. The County Councils' Association has added weight to this opposition by passing the following resolution :

" That the Council, while recognising the fact that the Road Fund revenues are increasing year by year and now stand appreciably higher than at the time that the fund was first established, desire to point out that the cost of highway administration has increased in an even more marked degree; that each advance in the Road Fund revenues must obviously be accompanied by additional road expenditure; and that there is still a very large mileage of roads which are entirely unsuited to modern traffic conditions, and cannot be adequately improved by the highway authorities without substantial financial assistance; (*b*) that the Council are, therefore, of opinion that the proposals of the Chancellor of the Exchequer are most ill-advised, and would, if adopted, result in a serious deterioration of the roads of this country; (*c*) that in these circumstances the Council do offer strenuous opposition to any diversion of the Road Fund and do request the Prime Minister and the Chancellor of the Exchequer to receive a deputation in support of the Association's views; (*d*) that the deputation do consist of the Chairman (Sir Arthur Chapman) and Vice-Chairman (Mr. E. R. Turton) of the Council, the Chairmen and Vice-Chairmen of the Parliamentary and Highways Committees (Mr. E. R. Turton and Mr. F. Dent, and Lord Strachie and Mr. F. H. Berryman), Lord Montagu of Beaulieu, Lord Deramore, Mr. J. Aspell, Major J. S. Courtauld, M.P., Mr. T. D. Fenby, M.P., Lieutenant-Colonel Watts-Morgan, M.P., and Sir Douglas Newton, M.P.

It is understood that the Association of Municipal Corporations is taking similar action and that a combined protest will in all probability be made.

Apathy alone can prevent the opposition from being overwhelming since the importance of a progressive road policy has been established beyond doubt.

Contractor's Record, Nov. 4th, 1925.

WHITE LINES.

Speaking at Bournemouth, Lieutenant-Colonel Ashley, Minister of Transport, referred to the scheme for reducing road risks by the use of white lines at curves and crossings. " The experience already gained in the use of these lines showed," he said, " that they must be counted upon not only to reduce risks, but also to assist materially in the control of traffic by the police. But if the scheme was to be of any real benefit, it involved rigid adherence by all motorists to the driving instructions conveyed through the medium of the lines. Another necessity for the success of the scheme was that there should be as great a degree as possible of uniformity throughout the country as to the use of these lines."

In this connection it is interesting to note that steps have already been taken by the Ministry's divisional road engineers to obtain and collate the views of local authorities and in addition the County Surveyors' Society, and the Institute of Municipal and County Engineers have been asked to consider the suggestions made. So soon as the views of the various associations representative of the road authorities throughout Great Britain have been obtained, and considered, the Minister proposes to issue a circular letter to all authorities concerned with a view to standardising the use of white lines throughout the country.

***Contractors' Record, Nov. 4th,* 1925.**

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